CERAMICS

APRIL
1951

. 26 Vol. III

(AP)

ONDON

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A monthly journal covering the whole ceramic field including pottery, glass, heavy clay, refractory and silicate industries.

Published Monthly by ARROW PRESS LTD., 29 Grove Road, Leighton Buzzard

Price 2/6d. per copy. 25/- per year, payable in advance.

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APRIL, 1951

FEATURE ARTICLES

MISCELLANEOUS

Copy and Blocks should be available to us by 14th of the preceding month.

They should be sent to:

CERAMICS

29, Grove Road, Leighton Buzzard, Beds.

Telephone: Leighton Buzzard 2328/9.

Ceramics

VOL. III | APRIL, 1951 | NO. 26

THE "INDUSTRIAL PARTY" MANIFESTO

RECENTLY two men were talking together over a quiet drink, but instead of grumbling at the way British industry is hamstrung by its politicians they talked of an "Industrial Party."

Below is annotated a manifesto based upon their conversation.

1. The real saleable wealth of the community is created by management and men working together in an industrial productive enterprise.
2. The present make-up of the two political parties gives almost complete representation to economists, teachers, lawyers, doctors, financiers, trade union leaders and merchants. None of these has even a nodding acquaintance with the day to day problems of wealth production.
3. Although management and men earn the nation's wealth they have no say in its distribution or even in the acquisition of its vital raw materials.
4. Although management works may be FOR the owner (private or nationalised) it nevertheless works WITH the men so that both have a common interest in the job. This common interest should be extended so that each is reimbursed in a manner related to the productive output of the factory.
5. Membership of the new "Industrial Party" is open to management and men whether trade unionists or otherwise and including manufacturers so long as they are playing an intimate part in the wealth production process.
6. Wage rates would be fixed by agreement among the different industrial groups and the "local" element would be highly important. The

primary question in determining wage rates for both management and men would be productive output related to gross profit. Each productive unit should be autonomous in this respect for undue centralisation breeds inefficiency.

7. The members would know just what they needed in terms of education, social services and home affairs. To this end they would enlist the services of experts.
8. Their export manager members would make much better diplomats through their overseas contacts than the present political stereotypes.
9. An important point in their programme would be to limit drastically the hosts of middlemen bureaucrats each of whom is an extra burden upon productivity.

Looking at the whole thing in retrospect it seems to settle the thorny question of a class society and realises that in the end we all depend upon increased wealth production for an increase in our living standards.

It is hoped that the conversation of these men will not pass unnoticed and that they will make converts, for at least a few M.P.'s like them would fill the present House of Commons more adequately.

Maybe they would restore its dignity for now about the only job which requires neither training nor experience is that of a Member of Parliament!

In the past there have been many references to a "business men's Government," which have been treated with derision because it was suggested that in the end it would be a "financiers' Government."

Here this has to some extent been avoided. Basically the problem today is some kind of compromise between wages, profits and productivity, but these have been divorced in their national administration because the administrators are not drawn from the industrial productive field.

Any enterprise consists of its operatives on the factory floor, its management grades and its higher executives covering the sales, export and technical problems. Here there exists a wealth of practical experience far and away more realistic and useful to the nation than the paper jargon of the politico-economists.

The association of profits, wages and productivity should react favourably upon men, management and executives in the particular factory concerned. Sensible bonus payments in which increased productivity resulted in higher wages all round is an obvious advantage to the community.

Eavesdropping upon this conversation proved interesting, for obviously today, when Britain is in the throes of a social revolution, its old-fashioned ideas on party politics and education, the age-old arguments between capitalist and the exploited working class, and the struggles between the "haves" and the "have-nots" is out-of-date.

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COMMENT

by **ARGUS**

MARK HARTLAND THOMAS, Chief Industrial Officer to the Council of Industrial Design, has just published an article in the Council's journal *Design* relating to the Festival of Britain Pattern Group. He states that crystal structure diagrams are "the maps that the scientist draws to record the arrangement of the atom in particular materials. The crystal structure diagram takes the form of a repeating symmetrical pattern like a wallpaper."

Some time ago, a weekend course was held by the Society of Industrial Artists when Professor Kathleen Lonsdale talked on crystallography, and pointed out that crystal structure diagrams might be used for textile designs. One of her colleagues, Dr. Helen Megaw of Girton College, Cambridge, had already drawn out some diagrams as a basis for decoration.

Mr. Thomas was impressed! To quote him, he said: "So I told him (Ian Cox, Director of Science, Festival of Britain) how I was planning to steal some of his scientific thunder and apply it to mere industrial art—Jupiter's fire degraded to Vulcan's forge."

Waste Paper

Need I go on to extract from this puerile dilettante nonsense which is being churned out by the Council and the Festival of Britain Public Relations Officers, using up tons of paper which no one else can obtain. It seems indeed that the boys are having one whale of a time stimulating their innate sense of artistic appreciation. Simultaneously they teach their textile grandmothers in Lancashire to suck eggs, they achieve the impossible feat by shaking both legs in the air at one time and very soon they will descend upon that rotund part of their anatomy in the very realistic mud of Battersea Park. To turn a phrase "Never has so much twaddle been talked by so many artistic types in a world where we are fast trying to produce more and more out of less and less."

Indeed let us hope that the Festival of Britain will be a success, for we do not wish to see another few tens of millions disappear like the ground-nuts in Africa. But, if it is a success, it will be due to the tradition, enterprise and vigour of British industrialists and those engaged in the production of British wealth. It will be in spite of this gang of long-haired planners who have nestled themselves into a very comfortable furry nest at Petty France, which I feel is sure to go up in flames when the last light is dimmed on the mud-bank at Battersea. Nero with his fiddle was a realist indeed compared with such as they! Someone has suggested that the fun fair should be left as a permanent monument to the Government!

Design for Festival

And just to drive home my point more forcibly!

The Council of Industrial Design have for quite a while had the audacity to tell pottery manufacturers of note precisely that which they ought to design—of course at the expense of the manufacturer! Recently I had the opportunity of

going round the factory of one of the well-known names in the fine china industry. Somewhat jokingly they showed me their exhibit for the Festival of Britain which had been accepted! The joke was that they had designed a piece of ware which they thought would be accepted by the Council itself! In forecasting the taste of the Council they had been successful for the exhibit was chosen, but they hastened to add that it would never see the light of day in production, because in their opinion it was not that which their overseas markets wanted!

This is the sort of thing one gets when an outside body like the Council of Industrial Design thrusts itself upon a trade. Pottery exports—and the fine china exports in particular—go up and up due solely to the tradition, background and overseas contacts of the industry itself, although they are compelled to waste their time in making exhibits they will never produce simply to satisfy the Council's cultural creed!

A Few Shots Left

I know that in many quarters I stand accused of taking an unnecessarily churlish view of research programmes. However, I stand unchastened at the thought of any broadsides which might be launched. There are still a few shots left in the ammunition belt! After all I have only contended that technology—by which I mean the alliance of pure science and industrial practice—rather than pure science, is our greatest need today. Strangely enough, when it comes to that 20th century wonder of science—atomic energy—support for my contention is forthcoming from no less a person than the expert, Professor Oliphant.

He said recently in Australia that the application of nuclear power to industry is no longer a question of research but of technology. Note the words! Then listen to Sir Henry Tizzard who makes the statement that "It will be 20 years before atomic energy can give us much benefit." In these two opinions comes the answer to the relative importance of research and technology!

Frankly the fundamental research part is easy, providing a pleasant pre-occupation in which the worker is unworried by balance sheets and the necessity of showing a profit. The research worker deals with milligrams and the development engineer or technologist with tons! It is the difference in these weights which represents the difference between the money which should be spent relatively in research and development, both in terms of training and in terms of fundamental research itself!

I have never contended that fundamental research should be abandoned or that no one should be trained for this important work. All I have said is that the universities are practically our sole source of higher executives in industry, and they are training all their students for research and none for technology!

A Trained Mind

I have had it put to me that the pure science course produces a trained mind which can then turn its attention to technology. My reaction to that is that an applied science course related to both theory and practice would in the end produce better research workers than we have today, and more useful executives in the sphere of wealth production. It is not a new idea! It is not revolutionary! It is merely what has happened in Scandinavia, Switzerland, Germany, Holland and in America and in fact what has been happening for a good many years.

The accusation levelled frequently at the British is that they do the spade work and it is left to those other countries to convert their research to economic practice. Cash in—if you like. It is my contention

that the main reason for this is that our system of technical training does not give that breadth of appreciation of the importance and problems of actual wealth production which is necessary. The research worker still has the audacity to look down upon production management and workers who earn the wealth of the Nation.

Semi-Blackmail

And talking of training, it comes to my ears that there is a certain amount of semi-blackmail going on in recruiting science graduates from the universities. There is a mad scramble for them and competition waxes severe from the larger groups in private industry, from the research associations, from the universities, from the nationalised boards and from the scientific Civil Service. Year by year each dangles a larger and larger carrot before the graduates, but I am informed by some university appointments officers that the scientific Civil Service has a secret weapon! I am led to believe that if a university graduate will contract himself to the scientific Civil Service for 6 years he will be granted a remission of his Service training! If he goes to private industry this remission is not granted.

Of course this is not written down as an edict, but it is confirmed from another friend of mine recruiting university graduates for a private firm. Of course I may be wrong and if so, no doubt this statement will be questioned. But we will see what we will see!

Forecasts

The Department of Scientific and Industrial Research of the National Boards now have most elaborate Public Relations Departments. There was a time when so called scientists were most hesitant to forecast the results of their experiments.

But this is no longer true today! The Ministry of Fuel and Power would have us believe that underground gasification of coal and the subsequent use of the gas produced by a gas turbine engine was well advanced. Yet the man on the spot, publishing his paper in the journal of the Institute of Fuel states quite categorically that no attention has been given to this latter part of the problem.

The Chemical Research Laboratory discovered some sulphate reducing bacteria in clay which was the partial cause of underground pipe corrosion. As an incidental sulphur was produced, the D.S.I.R. publicity - mongers seized upon this for a press release and the national dailies carried the story that the backroom boys at Teddington had invented a means of producing sulphur without its import.

Government Propaganda

This publicity angle of D.S.I.R. has become nothing more than pure Government propaganda. The tentative results of scientific investigators are written up in headlines merely to mislead the public into thinking that the State "backroom boys" are achieving wonders. But make no mistake, the intention is not to pat these boys on the back. When they fall for this flattery they are becoming the unwitting dupes of a Government which is fast attempting to inculcate the pernicious ideology of State worship.

A Menace

If our present system of scientific training has produced products who for one reason or another are misled to support such an unscientific, dictatorial and inhuman philosophy it is surely but another indication that their training system is wrong. Now far from becoming merely an expensive luxury, it is becoming a menace to those who believe in a relatively free society and who detest this dangerous State worship complex which is permeating our lives at school, at home or at work!

Development Councils

by

W. F. COXON, M.Sc., Ph.D.
(EDITOR OF "CERAMICS")

ALTHOUGH the question of a Development Council for the Pottery Industry has often been discussed in general terms, the true implications, the ideas and functions behind such a Development Council are often not clearly understood.

As will be remembered, a few years before World War II, there was an intensive trade union movement supporting the scheme of workers participation in policy-making —a kind of half-way stage towards the older idea of workers' control, which in turn derived from syndicalism.

Industrial Boards

In 1944 the T.U.C. issued an "Interim Report on Post-war Construction." Basically its thesis was to set up a number of Industrial Boards covering many industries, which were to be recognised as the bodies responsible for the internal regulation of the industry and to form a liaison between the particular industry and the Government. They were to contain an equal number of representatives of employers and workers, with an independent chairman and a small number of other independent members. Their function was to include the general planning of the industry to ensure maximum production. In addition they would advocate a common research organisation, pooling of improved methods and the planning of technical education. They could undertake an exchange of commercial information, market research, export requirements and the standardisation and co-ordination of costing information. They might be responsible for the organisation of joint marketing, the establishment of purchasing agencies, the pooling of transport and an arrangement of common credit and insurance services. An important point was that negotiation of wages and conditions were specifically excluded from the activities of these Boards.

Undoubtedly it was Sir Stafford Cripps, then President of the Board of Trade, who was the main inspiration behind the Industrial Organisation and Development Act of 1947, which on its third reading was passed unopposed in Parliament. He it was who instituted the Working Parties, and 17 were set up during 1945 and 1946, with identical terms of reference, including the examination and enquiry into schemes and suggestions for improving the organisation, production, distribution and processing of the various industries. Again wage negotiations were excluded! As a result, eleven of the Working Parties recommended some form of central body for their particular industry.

"Enabling" Measure

It is important to realise that this 1947 Act is really an "enabling" measure, which permits the President of the Board of Trade and certain other Ministers to set up Development Councils for particular industries by Order! Up to 1951 seven Orders had been made for setting up Development Councils for cotton, jewellery and silverware, furniture and clothing. In one case (clothing) the Council was set up in the face of strong opposition from the industry itself.

According to the Act, a Development Council consists of members in the following categories:*

"(*a*) persons capable of representing the interests of persons carrying on business in the industry;

"(*b*) persons capable of representing the interests of persons employed in the industry, and

"(*c*) other persons, being persons as to whom the Board or Minister concerned is satisfied that they have no financial or industrial interest as is likely to affect them in their discharge of their functions as members of the Council (in this Act referred to as 'the independent members')."

Provision is also made for the inclusion of representatives of distributing interests. The chairman is required to be one of the independent members. The numbers are not fixed but the first two categories must form a majority of the Council. Appointments are made by the Minister, who is required in every case to consult the appropriate organisations of employers and workers.

Composition of Existing Councils

As actually constituted, the composition of existing Councils is as follows:

Cotton: Four employers (one from each section); four employees (one from each section); three independent members. Total 11.

Jewellery and Silverware: Four employers (one from each section); four employees (unspecified); three independent members; one distributor. Total 12.

Furniture: Seven employers; seven employees; three independent members; one distributor. Total 18.

Clothing: Six employers (three from heavy section, two from light section, one from rubberproofed section); six employees; one representative of managerial and technical grades; four independent members; one distributor. Total 18.

Clothing, it will be noticed, is the only case in which there is special representation for the managerial and technical grades. In all other cases these are covered by the employees' representatives.

It will be noted that the weak spot in these Councils is undoubtedly that although employers and employees are equally represented only in one case, namely Clothing, has there been any special representative for the managerial and technical grades. These have been considered in the employee representation. It can, of course, be argued that a managing director with a nominal share holding in the business is paid for his services as a managing director and not as an owner, and he is just as much a workers' representative as the manufacturers! This is just one fallacy in the Act.

Independent Members

The idea of independent members was to prevent the industry from getting together against the Public, and they were drawn largely from the ranks of lawyers, accountants and economists. Obviously this was untenable in practice. If the discussions covered the commercial and technical structure of the industry, the independent member knew nothing and was unable to participate. On the other hand, if he knew something about the industry from experience he was hardly independent, and it seems to be generally agreed from the three Development Councils, which have had appreciable experience, that the independent members have not been anything like as useful as was envisaged.

It is, for example, difficult to imagine independent members being of value in a Development Council for the pottery industry. The struc-

* *Political and Economic Planning, 16 Queen Anne's Gate, London, S.W.1 — "Development Councils."*

ture, geographical location, conditions of work and the type of product is intensely specialised. Obviously the independent member must know something about the industry, although the moment he gains this experience he loses his independency. As a representative of the Public on the Council, an independent member should have the interests of the public at heart, and therefore would be interested in expressing their views, which can be succinctly expressed as "m o r e decorative pottery at as low a price as possible." In fulfilling his function, he would be opposing the Board of Trade on the one hand and possibly both manufacturer and the employee in the industry on the other. For example, the British public does not take kindly to the excuse given for higher prices in coal and gas as the payment of higher wages to the miner! Christian charity has not permeated the public to that extent!

Therefore one questions the value of the independent member as being able to represent, let alone protect, the public.

Compulsory Provisions

In so far as the Act is concerned, Development Councils have only three provisions which are compulsory. First is the registration of the firms with the Council and their names to be open to public inspection. Secondly, a compulsory levy to defray the expenses of the Council, and thirdly that the firms must supply returns, records of their activities and make their books available for examination by the independent members of the Council or its staff, with some safeguards against disclosure.

It is probably in the last category that firms understandably take objection to the idea. The Ministers of the Crown very frequently refuse to answer questions in Parliament on grounds of public expediency, and likewise the structure of any industrial organisation is such that an open inspection of its books might be disastrous to the firm concerned, and incidentally to its employees. A worrying overdraft, negotiations to keep in business as a result of adverse circumstances which can be overcome if not generally known, but which would be aggravated if the true state of affairs leaked out, has been the position of practically every business at one time or another. A run of creditors who had heard that things were slightly difficult is enough to crash even the largest organisation.

Frankly, this idea of inspection is dangerous in the extreme to both manufacturer and employee, and it is difficult to explain why the Development Council needs such details from its members, any more than an employee joining his trade union should be expected to divulge the nature of his earnings, his Post Office savings or any other personal matters. It is in this inspection that a strong argument has been developed against the Development Councils. It has been said that when all this information—some financial and some technical—has been neatly co-ordinated, the industry is ripe for some form of State control. For what other reason does the Government need this information?

Wages and Conditions

The question of wages and conditions of employment, although excluded from the terms of a Development Council, obviously play an important part in any industrial enterprise. One feels that with a Development Council the trade union movement gains much, yet by ensuring a separate negotiation on wages and working conditions the trade union hierarchy maintains its rights whilst expecting the manufacturers to give up something of equivalant importance to them.

Apart from these three compulsory functions, there are many other possible functions, such as research,

marketing, standardisation, training, recruiting, safety and so on.

Manufacturers' suspicions are further aroused by the suggestion that the Development Council will liaise with the Government to advise on any matters relating to the industry which *the Minister might request!*

The Pottery Industry

Referring, therefore, specifically to the pottery industry and its reaction to the idea of a Development Council, the first compulsory provision, namely, the registration of names, is already accomplished in many independent publications. The second proviso merely envisages the industry keeping a further body of bureaucrats. The third provision, seeking as it does private information about various firms, is pernicious, and one cannot imagine why the information is required by His Majesty's Government even for statistical purposes. When it comes to the optional functions, many of these are already in existence. Research, for example, is covered by The British Ceramic Research Association. On fine china exports the Group have got together. On the question of interchange of processing and knowledge, the logic of the social reformer seems realised, but in the end pooling "know-how" means merely penalising the highly efficient and subsidising the highly inefficient to produce a dull, drab mediocrity, which is neither fish, fowl nor good red herring.

Appalling Weakness

The exclusion of management representatives is an appalling weakness of the Development Council as defined in the Act. Representation can never be complete with only manufacturers and employees represented. On any major issue the chairman would have to use his casting vote, but management in the case of the pottery industry, represented by the British Pottery Managers' and Officials' Association, would stand in the middle. They can take the long view.

As has been said before, they work for the manufacturer but with the workers, and on any point of issue it would be a rash man who said that they were going to vote wholeheartedly for either one side or the other. If anything, they would be in a position whereby they formed a link between what the President of the Board of Trade calls the two sides of industry—he refers to manufacturer and worker.

It is hoped that in compiling these short notes the full implications of a Development Council will be more fully realised, for obviously the subject introduces far-reaching problems which can easily very adversely affect the manufacturer, manager and employees in the industry.

An agreement between the Federation, the Society and the Managers' Association arrived at between them might be far more desirable in the end than the arbitrary enforcement of the 1947 Act by the Minister himself which would mean a back door entrance for Whitehall into another industry.

A PRIZE OFFER TO DESIGNERS

MR. H. M. R. NEWTON, director, writes as follows: "Thos. Parsons and Sons Ltd. offer a prize of 50 guineas for the best design which commemorates the completion in 1952 of the Company's 150th year of existence. The design should be suitable for posters, merchandise, and for over-printing on stationery and advertising matter, and must be accompanied by a further design in bold lettering comprising either the full title of the firm, or the word "Parsons."

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CRAZING AND CRAZING RESISTANCE

(SPECIALLY CONTRIBUTED)

PIECES of old pottery ware frequently show crazing, and on some of the pieces it has a certain decorative effect which is sometimes imitated in modern times and called "crackle glaze."

Crackle Glaze

This is a glaze rich in alkalis with a relatively high expansion coefficient compared with that of the body, and on cooling it therefore cracks or crazes. A typical formula for a crackle glaze is:

Frit	*Glaze*
Borax 75	Frit 40
Stone 23	Whitehead 45
Feldspar 8	Stone 15
Whiting 5	
Soda ash 32	

This matures at Seger cone 06a and gives a fine network of small cracks over the glaze. In the normal way however, crazing is not welcomed by the potter, particularly that insiduous form of it which occurs some months after the ware has been sold, and commonly called delayed crazing.

Difference in Expansion of Body and Glaze

Essentially the cause of crazing is a difference in expansion between the glaze and body, but the matter is not as simple as that, and to get a clear idea of the methods adopted to prevent crazing we must first consider the body on which the glaze rests.

It may be stated at the outset that crazing is a problem which occurs more with porous than other types of ware. The reason for this will appear later, but for the moment we will consider a typical porous body such as earthenware. This is made from ball clay, china clay, flint and stone, and in the biscuit fire some of the free silica is combined with the fluxes in the body to form a glassy material which binds the body together and gives it its strength.

Cristobalite Formation

Some of the silica remains in the free state as quartz, and some of it is converted to another form of silica called cristobalite. It sometimes causes some confusion when we speak of cristobalite formation occurring in biscuit firing, since equilibrium diagrams show that with pure silica it does not form below 1,470° C. With microcrystalline forms of silica like flint, especially in the presence of substances like lime and iron, which catalyse this reaction, it proceeds at a lower temperature.

Changes in Crystalline Form Give Sudden Expansions and Contractions

We have then in the fired biscuit body free quartz and cristobalite, as well as various other materials. The significance of this is that these crystalline forms of silica show sudden expansions and contractions in heating and cooling due to changes in their crystalline form. Thus quartz crystals show a reversible change from the *L* form to the *B* form at 575° C. and cristobalite shows a similar change at around 200° C. These changes are accompanied by expansions or contractions, depending on whether the material is being heated or cooled,

and the cristobalite change is accompanied by a volume change of as much as 3 per cent. The curve obtained by plotting rate of expansion against temperature for a typical earthenware body is given in Fig. 1 and shows clearly the sudden changes in expansion rates which accompany these changes. On cooling a glazed body therefore, there will be a sudden body contraction at around 575° C. due to the *B* to *L* quartz change. At this temperature the glaze is still in a semi-plastic state and accommodates itself to the change.

The Cristobalite Squeeze

Around 200° C. the contraction due to the *B* to *L* cristobalite change ensues, and by this time the glaze is solid, so that the effect is to put the glaze under a compression. This squeeze is a very important factor in developing crazing resistance, since crazing is most likely to occur when the glaze is in tension.

How then does delayed crazing occur?

Moisture Expansion

Some years ago it was discovered that porous bodies exposed to atmosphere moisture underwent a permanent expansion. This for want of a better name, was called "moisture expansion" of a body. It will be evident that this expansion will release the compressive effect of the cristobalite squeeze, and in time may put the glaze into tension. When this happens crazing is likely to ensue. It may take a long time for the moisture to penetrate to the body, but it will surely happen, and if the moisture expansion is big enough delayed crazing may result.

Moisture Expansion Absent in Vitreous Bodies

So far we have mentioned cristobalite formation and moisture expansion as factors effecting the

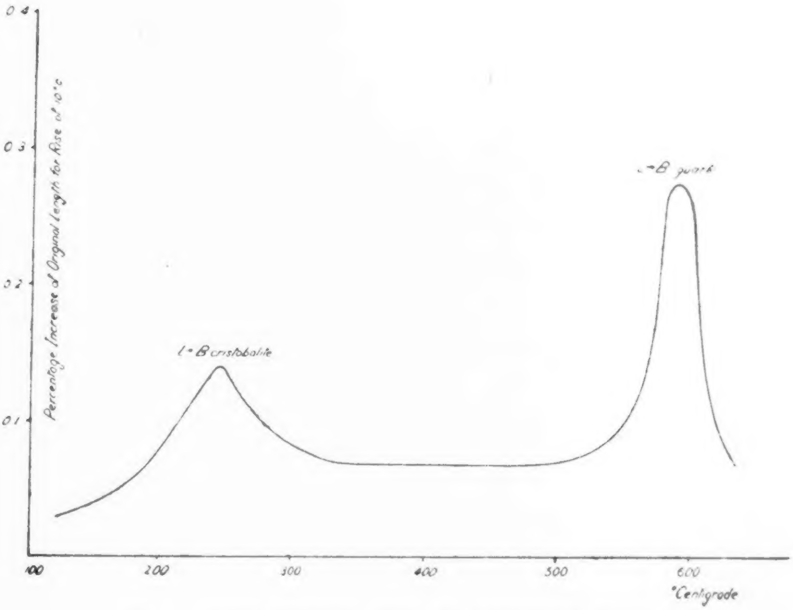


Fig. 1. Typical expansion curve for earthenware biscuit

liability to crazing. These are probably the most important single factors in connection with crazing resistance. With vitreous bodies the moisture expansion is absent and we hope that there is no free silica present, so that crazing resistance in these cases must depend on a good match in the expansions of body and glaze. With porcelain, for example, the body and glaze have somewhat similar compositions and are usually matured together. In such a case the glaze and body expansions are similar and crazing is infrequent. When it does occur the fault is often due to errors in glaze or body mixing affecting their expansions.

Buffer Layer Formation Important

There are however, certain other factors which influence crazing resistance of porous bodies. These are the influence of the elasticity of the glaze, and the effect of the so called buffer layer, which is that region where the glaze and body intermingle. Very little is known on the question of elasticity, but it appears that the development of a good buffer layer can decrease the tendency to crazing. This has been shown by making up a glaze with frits of varying hardness on the assumption that the softer frit would combine more readily with the body to give a sound buffer layer. The glaze containing the softer frit showed a greater crazing resistance. In actual practice it is found that unless the glost firing is adequate (i.e. to a certain B.R. No. for example) the crazing test results suffer. This is presumably because the necessary heat work to form the buffer layer has not been done.

Assessment of Crazing Resistance

What methods are available to assess crazing resistance? Unfortunately there is no standard test, and we have no indications of what the various tests used in practice mean in terms of useful service life. What tests are used can be treated only as yardsticks to indicate that a batch of ware is as good as a previous lot which gave good service. As such these tests are perfectly good for routine works control though unfortunately, they do not usually permit the comparison of results from other works where a different crazing test is used. Moves are on foot to study crazing tests to decide which of the many is likely to give the best indication of crazing resistance. When this is done it should be possible to standardise this test, and to compile a specification for it.

Let us now consider the methods available for obtaining information on the resistance to crazing which is likely to be obtained from glost ware.

Calculation of Glaze Expansion

It is possible to calculate the approximate coefficient of expansion of a glaze from the molecular formula using the fact first shown by Winkelmann and Schott (*Ann. Physik Chem.* **51**, 7, 30, 1894), that the coefficient of expansion of a glass is an additive property. This means that to each component of the glass or glaze can be assigned a factor, or expansion constant, and by multiplying these by the appropriate percentage of the component, and adding together the products the expansion coefficient is arrived at. Expressing it mathematically we get:

Coeff. of thermal expansion (cubic)

$$= p_1E_1 + p_2E_2 + p_3E_3, \text{ etc.},$$

where p_1 is the percentage of component whose expansion factor is E_1 and p_2 is the percentage of component of expansion coefficient E_2 and so on for as many components as the glaze contains.

Figures for the expansion coefficient or factor as given by English and Turner (*J. Amer. Ceram. Soc.* **10**, 551, 1927) are given on next page:

	Expansion Coeff. $\times 10^{7}$
SiO_2	0·15
Al_2O_3	0·52
B_2O_3	(−1·98)
Na_2O	12·96
K_2O	11·7
PbO	3·18
ZnO	0·21
CaO	4·89
MgO	1·35
BaO	5·2
ZrO_2	0·69

It is to be noted that the alkalis contribute high values to the glaze expansion coefficient and such glazes in fact, usually craze on a normal pottery body and require one richer in silica with a higher expansion for good results.

The calculated expansion coefficient using the above method is somewhat uncertain with glazes involving B_2O_3.

Limitations of Expansion Coefficient Valves

Such a calculation will obviously give information about a gross misfit between body and glaze, but unfortunately we are not usually confronted with such an obvious source of trouble. There is also no information available as to what difference in expansion bodies and glazes will stand without crazing, or indeed of what difference is desirable to avoid delayed crazing. Calculated expansions are therefore of little use for controlling production. Another obvious method is to determine the coefficients of expansion of body and glaze. This however, is a time-consuming job, and it suffers from the same objections stated above, though this is not to say that it does not give the potter useful information in other directions.

Bending of Ceramic Body Due to Glaze Pull

Other methods available involve the bending of clay bodies glazed on one side only due to the pull exerted by the glaze. In one of these a

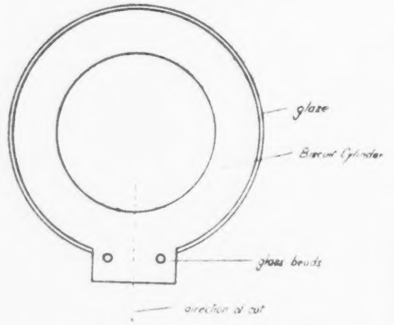


Fig. 2. Calculation of glaze expansion

hollow cylinder is glazed on the outside and two glass beads are cemented on. The distance apart of these is measured with a microscope and the cylinder is cut through. If the glaze and body do not fit the distance between the beads will alter (Fig. 2).

In another method one side of a biscuit bar is glazed and the whole is then heated in an electric furnace. A pointer is attached to the end of the bar reading on a scale (Fig. 3), or some mark is made on it which can be focused in a travelling microscope. As the bar is heated up any difference in expansion between body and glaze shows up as a bending of the bar which can be followed by the pointer or in the microscope (cf. W. Steger, *Ber. deut. keram. Ges.* **9,** [4], 203, 1928 and A. M. Blakeley, *J. Amer. Ceram. Soc.* **21,** 243, 1938). This is again a method hardly suitable for routine factory control.

Heating and Cooling Tests

For this purpose we are driven on to simple heating and cooling tests. These may consist of merely heating and cooling the ware, but nowadays in this country it is usual to combine the effects of moisture expansion and thermal shock by some such treatment as heating in steam under pressure, followed by cooling in water. This gives a result in a convenient time, so that production can be constantly checked. There is variation from works to works in the steam pressure used, and in the procedure of grinding. Some workers use pressures like 50 lb./sq. in. for 1 hr. followed by cooling in water and record the number of cycles required for crazing to ensue. Most samples of earthenware will stand twelve cycles under these conditions, and some go up to 20 cycles. Others prefer to record the number of hours steaming at a given pressure, without cooling cycles, which are required to give crazing. There is as yet no evidence as to which test is preferable, and some authoritative statement on the matter and standardised test is desirable.

What these tests mean in terms of service life is uncertain—the most that can be said is that ware which has stood say x heating and cooling cycles has produced no complaints, and therefore the test is used as a

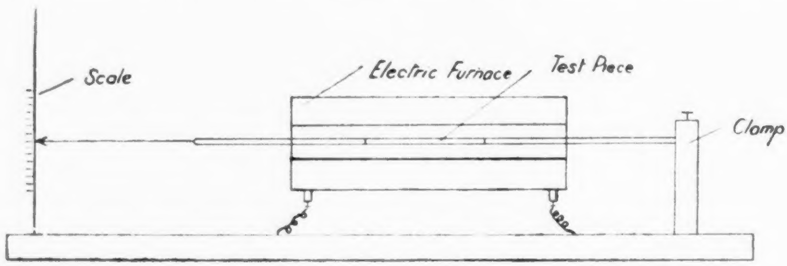


Fig. 3. Apparatus for investigation stress in glazes. (W. Steger. Ber. deut. keram. Ges. 9 (4) 203. 1928)

means of producing ware of similar performance which it is expected will give similar satisfaction.

Correlation of Crazing Test with Service Life

An attempt to correlate a crazing test with service life was made recently in Hungary by L. Mattyasovsky-Zsolnay (*J. Amer. Ceram. Soc.* **29,** 200, 1946), who carried out autoclave tests on old wall tiles. He concluded that if a tile will withstand 100 lb./sq. in. of steam for 2 hr. it is unlikely to craze in 20 years. The same author concluded that 1 hr. at 150 lb./sq. in. is equivalent to 3 hr. at 100 lb./sq. in., and that 1 hr. at 100 lb./sq. in. is equivalent to 4 hr. at 50 lb./sq. in. Evidently then higher steam pressures constitute a severe test of ware.

Sporadic Outbreaks of Crazing

Outbreaks of crazing occur sporadically on works, and the problem is how to tackle the matter so as to cure it in the shortest time.

Usually the first thing which the management looks to is the firing. Easy fired ware is shown up by being oversize and having a porosity higher than normal. Consequently these are routine checks well worth doing. When trouble occurs these checks however, cannot be done unless some of the biscuit from the same oven remains in the warehouse. They should be done on subsequent ovens before glazing in case these have also been underfired. It should be noted that the high porosity in itself is not the cause of poor crazing resistance. The incorrect firing affecting the cristobalite formation is the actual cause, and the high porosity is the outward sign of this. If tests reveal that the firing of biscuit is easier than it should be the remedy for the crazing may be harder fire. If there is no evidence that the biscuit firing has varied it may be well to check the glost firing records. Variations in this may lead to poor buffer layer formations, which may be a cause of crazing.

Importing of Silica Content in Body

If the firing seems to be correct as judged by previous records, it will be necessary to check whether there has been some error or variation in the body mixing.

Here the silica content is the first check required since the amount of free silica present determines the likelihood of an adequate cristobalite formation. In general it is found that a total silica content of 73-75 per cent. in the fired biscuit normally ensures sufficient cristobalite present to give good crazing resistance.

If analysis reveals deficiency in total silica the remedy may be to determine why the silica is low and if necessary to increase the amount in the mixing. Care must be taken in this direction, however, since silica increases the expansion of the body and if too much is added the glaze may peel off the body.

Causes leading to deficiency of silica in the body are such things as changing the ball clays or stone without reference to the chemical analysis of these materials. The silica contents can vary with different types, and their indiscriminate use can lead to silica deficiency with crazing as a result.

Variation of Specific Gravity of Flint

Other possible causes of variation in the biscuit body are variations in the specific gravity of the flint due to calcination. Since flint is normally mixed in slop form this can lead to variations in the dry weight of flint added to the mixing in accordance with Brogniarts formula. Overfiring causes the density to fall, and at a constant pint weight this results in adding more flint to the dry recipe. Underfired flint of a higher specific gravity than normal results in adding less to the mixing with consequent likelihood of crazing. Variable calcination may re-

sult from the loading of the kiln, a change in the type of flint used, and wind velocity when burning is in progress.

Grain Size of Flint Needs Checking

The fineness of grinding of the flint also needs checking since underground flint does not convert so readily to cristobalite, and the effect is similar to that experienced with a deficiency of flint in the body, i.e. crazing may result. Normally flint for earthenware is ground to a surface factor of 220-250. Variations in grinding may arise from the pavers and runners in a fan being worn, or to lack of attention to the relationship necessary between charge, pebbles and water in cylinder grinding (cf. CERAMICS, Vol. 1, January, 1950).

Alteration of Glaze a Last Resort

As a last resort it may be necessary to alter the glaze composition to make its expansion coefficient more in keeping with that of the body. This should only be done after all other possible causes of crazing have been checked and found correct, since it is easier to alter body mixing, etc., than glaze composition. A working rule is that anything added to a glaze which hardens it as regards maturing temperature decreases its expansion and hence its tendency to craze on a normal body. Thus pitchers, china clay and flint added to a glaze tend to improve crazing resistance.

A systematic check of all these points in order should lead to a cure for crazing but the process must be one of intelligent elimination of possible causes one by one until the correct solution is obtained.

Building Research Congress.—The organising committee of the Building Research Congress to be held in London in September is to consider closing the membership list for the Congress. More than a 1,000 delegates have already accepted invitations to attend.

British Pottery Managers' and Officials' Association

ANNUAL MEETING

THE annual meeting of the British Pottery Managers' and Officials' Association was held in Hanley Town Hall on Wednesday, 7th March.

The retiring president, Mr. S. E. Glover, after paying tribute to the help and support given to him during his year of office by the Association officials, handed over his position as President to Mr. H. Hulse, who will preside for the coming year.

Mr. J. S. Adams presented the statement of accounts for the year and noted that membership had increased by 51 during the year. He urged that fresh efforts be made by all to make the Association stronger numerically, and suggested that a target of 1,000 members was not too high.

Mr. F. Timmins, general secretary, gave his annual report during which he stated that negotiations with the British Pottery Managers' Federation on managers' salary levels were nearing completion, and that Civic recognition of the Association had been granted during the year.

The following officials were elected to hold office for the coming year:

President Elect, Mr. D. Salt.

Business Manager, Mr. J. S. Adams.

General Secretary, Mr. F. A. Timmins.

Auditors, Mr. T. A. Pimlott and Mr. A. Handley.

The meeting concluded with a discussion of internal business.

STOKE AND HANLEY BRANCH

THE March meeting was held in Hanley Town Hall on Monday, 19th March. In the absence of the branch chairman, Mr. Llewellyn took the chair.

The main item on the agenda was the "Question Box," during which the following questions were discussed:

What causes "feathers" on ware from the glost oven? The opinions given on this indicated two possibilities, i.e the devitrification of the glaze or the sulphuring of the glazes. As it was indicated that the ovens were of the intermittent type, it was suggested that the following points should be watched:

The fire mouths should not be allowed to cool off during the fire, i.e. the gain in heat must be progressive, with no dropping back; and secondly, adequate ventilation must be ensured, particularly if the coal is high in sulphur-bearing pyrites.

A question about the use of humidity control in flat clay ware dryers started an interesting discussion, during which it was agreed that, in theory at least, it was desirable to do the initial heating in a humid atmosphere under some form of humidity control. The main point made was that the initial heating and the actual drying stages should be separately controlled and independent of each other as far as humidity is concerned.

Small bubbles in the glaze at the edge of china plates was another trouble discussed. The ware concerned was fired in an electric glost oven with an open setting. It was generally agreed that the first approach to this fault was to decrease the time taken in the fire from about 1,070° C. to the peak temperature of 1,100° C. It was pointed out that a slow fire tended to make the viscosity of the glaze higher, and any bubbles formed would have more difficulty in escaping.

The question of fine white dirt under the glaze of china ware was also discussed. It was suggested that the bone in the body had a bearing on this fault, particularly in conjunction with a hard biscuit fire. Most members had encountered similar faults but no clear-cut reason for its occurrence has been found, and no proved remedy could be given.

A question about the standardisation of the mix of oil and colour for underglaze printing was asked, and it appeared that little information was available on this subject, the first necessity being a synthetic oil which in itself would be of standard quality.

THE HISTORY OF MASON'S IRONSTONE CHINA

AT a recent meeting of the Stoke and Hanley branch Mr. S. E. Glover gave a talk entitled, **The History of Mason's Ironstone China.**

Tradition has it, he said, that Miles Mason was born in Westmorland in 1752, his father being a tenant of Sir Michael Freeman of Rydal Hall; and with interests limited to agriculture—unlike other famous Master Potters (Wedgwood, Spode, Minton) Miles had no early association with the manufacture of pottery—he did not grow up as they did, in an atmosphere of "throwing" and "turning," of kilns and ovens and glazes. Instead, as a young man in the early twenties, he came to Fenchurch Street, London, and opened a shop as an importer of Oriental china, known as Indian or Nankin Porcelain—Indian because it was carried by the well-known East India Co. and Nankin its main port of shipment. Probably it was the artistic instinct in Miles which led him to trade in porcelain—fine porcelain and artistry being so inextricably interwoven.

While Miles was at Fenchurch Street his family lived in Yorkshire, and during the same period he married the daughter of a merchant in a similar business to his own. Furthermore, he won great favour as a "supplier of the finest tableware to the aristocracy and gentry," for in the 18th century such people used Chinese tableware almost exclusively. It is of note that at this period pottery patterns were frequently designed in England and shipped to China for the ware to be manufactured, and then returned to England for sale.

It was a protracted business even for these unhurried days, but when war among nations broke out, when pirates and shipwrecks abounded and the seas were unsafe, when, too, crushing tariffs were imposed to pay for the wars, and the fear of Napoleon, Miles Mason was compelled to abandon his importers business as it was no longer profitable.

In Search of Experience

Mason was now approaching 40 years of age yet his purpose when abandoning the Fenchurch Street business was that he himself should manufacture the fine porcelain needed by his customers. So dis-

regarding his years and the profound and general belief that the earths of this country were not equal to those of foreign lands for the manufacture of porcelain similar to that of the Chinese, he apprenticed himself as a painter to Duesbury at Derby (Duesbury was at the height of his fame and had recently absorbed both Bow and Chelsea porcelain factories). There is an entry on the records of the Derby works that Mason left there in 1792.

From Derby, Mason went to Worcester in search of further experience. Thus in each of his two apprenticeships he chose a factory where only the finest porcelain was made, and in these factories he gained the necessary practical knowledge which served him so excellently when he started his own factory at Lane Delph—now called Fenton.

Exact Reproduction

In Park Street, Lane Delph, Mason bought a plot of land from the Bagnalls, a well-known Fenton family, on which he built a small factory—Victoria Pottery—and here he produced hard-paste porcelain, which was an exact reproduction of the porcelain which he had imported from China when he was at Fenchurch Street—true, hard, translucent porcelain—and called it British Nankin. He thus proved himself, in fact and in deed, a Master Potter. Although from the outset Mason manufactured other ware, this hard paste porcelain remains his cleverest achievement, and from a technical point of view it far exceeds his later productions of Ironstone China, which was a commercial success.

The best known specimen of his hard-paste is a double handled cup, cover and saucer decorated in gold with acanthus leaves and palmeits, and described as perfect in both texture and finish, a beautiful specimen of hard-paste porcelain. This was on view at the Victoria and Albert Museum, but is now on loan at the Williamson Museum and Art Gallery, Birkenhead.

Those of us who understand the difficulties of expert potting, and that such in those days was only considered possible to the descendants of generations of those who have practised the art, are the most amazed at Mason's speedy transition from an importer to a practical potter, and that he could in so short a time display such skill.

He used a Chinese mark for his important work, and a plain "Miles Mason" stamped in clay at the bottom of his other early ware.

Ware for Domestic Use

But Mason was not by any means relying on hard-paste for the success of his factory. He soon realised that while English clay was suitable, English conditions of firing hard-paste were eminently unsuitable for producing an article which could be sold at a profit. It is not known how much or how little of this kind of ware he made, but from the outset he strived incessantly to produce a less costly body which should have all the qualities of Oriental ware without its drawbacks.

Therefore, side-by-side with his hard-paste and his experiments he was making ware in bulk for domestic use. According to an invoice of his dated 1797, he manufactured dinner-services, teapots, jugs and vases. These he decorated in red and blue with Chinese designs of landscapes or figures and gilt borders or with the willow patterns.

He was also making English fine bone china, then in its early infancy.

There are specimens in the Victoria and Albert Museum of a tea-service with a gold key design, which bears a closer resemblance to fine bone china than it does to hard-paste.

Matching Imported Ware

By the autumn of 1804 Mason was so sure of the results of his untiring experiments in porcelain, of

its beauty and durability, that he advertised his willingness to match broken pieces of imported ware, in the London *Morning Herald*, 15th October, 1804.—"Mason's China. It has hitherto been the opinion, not only of the public, but also of the Manufacturers of this Country, that the Earths of these Kingdoms are unequal to those of Foreign Nations for the fabrication of China. Miles Mason, late of Fenchurch Street, London, having been a principal purchaser of Indian Porcelain, till the prohibition of that article by heavy duties, has established a Manufactory at Lane Delph, near Newcastle-under-Lyme, upon the principle of the Indian and Sève [*sic*] China. The former is now sold at the principal shops in the city of London and in the country as British Nankin. His article is warranted from the Manufactory to possess superior qualities to Indian Nankin China, being more beautiful as well as more durable, and not so liable to snip at the edges, more difficult to break, and refusable or unitable by heat if broken. Being aware that to combat strong prejudices with success, something superior must be produced, he, therefore, through the medium of his Wholesale Friends proposes to renew or match the impaired or broken services of the Nobility or Gentry, when by a fair trial or conjunction with Foreign China, he doubts not that these fears will be removed, and, in a short period, the manufactories of Porcelain, by the patronage of the Nobility of the Country, will rival, if not excel, those of foreign nations." "N.B.—The articles are stamped on the bottom of the large pieces to provent imposition."

Expansion of Business

Mason's courage, initiative, and perseverance were rewarded and his factory in Park Street became too small for his growing needs. He therefore built himself a larger and more suitable one in a commanding position at Victoria Square, Fenton, a little distance from his first factory which on 9th November, 1805 he advertised for sale in the *Staffordshire Advertiser*, in the same number which contained news of the victory and death of Nelson at Trafalgar — "CAPITAL POTWORKS TO BE LET. And entered upon at Martinmas next—All those compleat set of Potworks, situate at Lane Delph, in the Staffordshire Potteries, now and for several years past occupied by Mr. Miles Mason as a China manufactory, together with an excellent modern built sashed house, and necessary outbuildings, adjoining thereto. If more agreeable to a Tenant, there is a Gentleman who has been brought up to and acquainted with the Manufacture of China and Earthenware, and will advance from one or two thousand pounds, would join a person conversant in the business as a partner."

Here he used a fresh backstamp—Fenton Stone Works.

Thus Martinmas 1805 saw Miles Mason installed at his second factory and here he was joined by his eldest son, who, though only 14 years of age, was as actively persistent in research as was his father.

Patent Taken Out

But it was not until 1813 that the Masons were satisfied with the result of their prolonged investigations, and the patent for Mason's Ironstone China was taken out. According to the specifications this patented body consists of "Scoria or slag of Ironstone pounded and ground in certain properties with flint, Cornwall Stone and Clay and blue oxide of Cobalt." The introduction of ironstone gave the body its durability and also its name to the patent. As is well-known to dealers in antiques, there are more old Mason dinner services extant today

than there are of any other classic pottery, a fact that is attributed to the presence of ironstone.

There is, however, a wide difference between ironstone china and the true hard-paste porcelain which Miles Mason succeeded in making at his first factory, for porcelain is essentially translucent, as is also the quite distinct bone china, but Mason's ironstone china is not and never was translucent, although, as is rightly claimed for it, it is more durable and less likely to chip than true porcelain. Yet, in spite of the introduction of ironstone, the body during firing retains its beautiful shapes, its fine texture, and its marvellous depth of colour.

Miles Mason from the time when he built his first factory at Park Street lived at Fenton within only a short distance of his works, that being the custom of a Master Potter of those days.

He died in 1822 and is buried in Barlaston Churchyard—his gravestone reads thus:

Mr. Mason's Vault.
Miles Mason of Fenton.
Son of Wm. Mason of West House,
Dent, Yorkshire.
Died Feby 1822.
Age 70 years.

Underneath are added the names of the wife of his elder son, Charles James, and later that of George Miles. There is no mention of the wife of Miles Mason.

After the death of Miles Mason the firm was carried on by his two sons, G. M. and C. J. Mason, but George Miles Mason retired from the firm shortly after his father's death and Charles James was left in sole control.

Miles Mason's Sons

Miles Mason was the father of two sons—Charles James and George Miles. The family lived in a substantially built house near their

new factory at Victoria Square, Fenton—and they had the run of the works as was customary. They grew up familiar with kilns and ovens, with oven drawings and oven counts, with bodies and glazes, with the making of a cup or a vase from the plastic clay to the finished article; thus knowledge which their father acquired as a middle aged man, and with some degree of difficulty, came to them naturally with their growth.

At home the conversation would centre round their fascinating research for an improved body, the blend of certain colours, or the setting-in of an oven. At 14 Charles was taking an active interest in the conduct of the business, for boys matured early a century ago. He it was who eventually proved himself the leading spirit and practical man of the firm, and when in 1813, Charles being then 22, the patent for Ironstone China was taken out, it was in Charles James's name.

"Something Greater, Something Different"

Charles was a man who never rested content with a past achievement. He had a constant urge to try something greater, something different. Having been successful in obtaining a fine looking, hard, durable ironstone china, the first in the field with such a body, he proceeded to take full advantage of it. In addition to tableware, for which he found a ready sale, he made presentation vases, some of which are much sought after by collectors.

There was a wonderful vase in the Hanley Museum—it is panelled and Chinese in shape, standing 52 in. high, the cover having a Pagoda top and ornamented with Chinese decorations in delightful colours, the whole of it showing fine workmanship in every detail. In *Staffs Pots and Potters* the Rhead brothers comment on this class of Mason decoration is that "these richly coloured paterns have not been surpassed if approached on decorative quality."

Always using the firm's patent Ironstone China, Charles proceeded to make a variety of articles not usually associated with pottery. He made posts for four-poster bedsteads, cisterns for gold fish and immense punch bowls, which, in his time, were in considerable favour.

Ironstone China Mantlepieces

He also made mantlepieces, Chinese both in colour and character. Few of these, however, are to be found today, and one is led to think that Charles made them primarily, for the reception rooms of his own residence, in which he had them fitted. Two such mantlepieces are said to be in cottages in the neighbourhood of the Mason factory; one is in the showroom of Geo. L. Ashworth and Bros. Ltd. A fourth, however, is set in its rightful surroundings in the dining-room of E. Marks Esq., of Stoke-on-Trent. It is a most beautiful piece of work, its bizarre decoration and its wonderful depth of colour. The owner removed houses in the 1930's and took the treasured mantelpiece with him and in its removal found the C. J. Mason backstamp behind each piece. It has been in the possession of this family since 1840.

For a period Charles made use of a different body which he called Cambrian Argil, the clay for which came either from Wales or was a local product, and no one now knows definitely which is was. Several inferior clays, however, are found in and near Fenton, and old inhabitants are of the firm belief that Cambrian Argil is Fenton Clay. He used this clay to make dinner services and other articles—it has a white ground and is decorated with a blue pattern, some of it Willow, but the body is definitely inferior and the work more interesting than it is beautiful.

Charles married a daughter of

Samuel Spode and lived at Heron Cross, Fenton in a house known as "Mason's Cottage," writes his contemporary Simeon Shaw. The house however, according to Fenton standards was far from small, and was approached by a carriage drive which opened out of the Old Toll Gate Road, now Blurton Road. During the Chartists Riots of 1842 the cottage was pillaged, much of its panelling and furniture was burned, and one of the ironstone china mantelpieces was damaged; while Charles and his family had to take refuge in the house of his sister-in-law, Mrs. Spode. Some 60 years ago the cottage was demolished to make room for a block of houses; the mantelpieces were taken away and many valuable old prints and pictures were scattered.

The Mason family had considerable influence in Fenton, they owned property there and took their part in every public ceremony, as when the first sod was cut for the North Staffs Railway. It was Charles Mason who built the Fenton covered market and in many ways served the people of the little town in which he lived.

The Mason firm reached its zenith about 1840, Charles having then carried on the business alone for almost 20 years.

George Miles Mason

The second son, George Miles Mason, appears to have taken little active share in the business of the firm, although one of the early backstamps when the patent for Ironstone China was taken out was "G. M. and C. Mason" the father's name not appearing. Later the backstamp was C. J. Mason and Co., the Co. being his father Miles and his brother George Miles. Certainly George Miles's interest, such as it was, centred round the years of his early manhood. On his marriage he went to live at Wetley Abbey on the outskirts of Leek, and shortly after his father's death in 1822 he retired from the firm.

Chiefly he will be remembered as the father of George Heming Mason, A.R.A., who was born at Wetley Abbey in 1818 and whose pictures are of the Leek moorlands.

Heming Mason was a freind of (the then) Mr. Frederick Leighton, who gave him very considerable help. Some twenty of his pictures were exhibited in the Royal Academy, two of which are now in the Tate Gallery. His portrait by Valentine Prinsep, R.A., hangs in the National Portrait Gallery.

His interest, however, to us centres round the fact that in this grandson of Miles Mason is embodied the artist which existed in each member of the Mason firm, and which is reflected in the beauty of their work, its texture, its elegant design, and its wonderful depth of colour, without all of which the Mason's would never have remained satisfied.

And yet, as is so frequently the case, artistic genius and commercial success rarely go hand-in-hand, and in 1851 Charles James, the sole remaining Mason left in the firm, sold his treasured patent, his plant, his moulds and copper plates, everything of value, to Francis Morley of Hanley. Charles did not many years survive the break up of his factory. He died in February, 1856 at the age of 65 and was buried in the tomb of his father at Barlaston.

Broad Street Works

We now turn to the history of the Broad Street Works, Hanley, where these wares are still manufactured by Geo. L. Ashworth and Bros. Ltd. The factory was first built about 1720 by John and R. Baddeley, and is one of the oldest works in the district. The two brothers were very highly "censured for their extravagance in having a manufactory covered with tiles instead of thatch, and for being the first who

erected four ovens behind instead of only two." In spite, however, of this alleged extravagance, the brothers Baddeley seem to have been successful potters, and it was said that here the blue printed ware was first introduced, as was also the art of printing in oils. An interesting and valuable find was recently made on the works of a number of the old patterns crudely engraved on heavy stone slabs. It is possible that these were used before copper plates were introduced for transfer printing, and the discovery of these old stones affords an important link with the past. After John Baddeley's death in 1772, the factory passed into the hands of Hicks, Meigh and Johnson, who pulled it down and rebuilt it on a larger scale. One of these partners, Meigh, was granted a gold medal by the Royal Society of Arts in 1823 for making a glaze free from lead, and the firm was as prosperous as Mason was unfortunate. Agitation against the use of lead and endeavours to find a substitute for it is not of so recent a growth after all! The factory subsequently passed through the Ridgway family into the hands of Francis Morley, whose connection with the works dates from 1835. In 1851, as we mentioned above, he purchased the patent right, copper plates, moulds, etc., from C. J. Mason; had the latter, many of which are still in use today, very carefully repaired, and soon established a prosperous business in Mason Ware. He gained the first-class medal in 1856 at the Paris Exhibition, and 3 years afterwards retired, selling the entire business to Geo. L. Ashworth and Bros. Ltd.

The Ashworths were Lancashire cotton spinners, and had their chief interest in the textile industry. In or about 1882, their Lancashire business failed, and their financial embarrassment affected them so severely that they were compelled to sell their earthenware business. Mr. John Shaw Goddard was the purchaser, and he was joined a few years later by Mr. Frederic Lewis Johnson, as partner. These two gentlemen carried on the business under the old name of "Geo. L. Ashworth and Bros." until 1914, when the business was formed into a Limited Company, and John Vivian Goddard and Walter Bakewell became partners. Mr. Johnson died in 1915, and in 1920 Mr. J. S. Goddard retired leaving John Vivian Goddard and Walter Bakewell alone in the business.

The writer is indebted to the directors of Geo. L. Ashworth and Bros. Ltd., for their courtesy and help in the compiling of these notes.

Acknowledgement was also paid to previous works by Mrs. Beardmore and the late J. F. Price, Esq.

WILCO-WIGGIN THERMOMETAL

THIS booklet was first published in 1947 and has recently been reprinted and published by Henry Wiggin and Co. Ltd., Wiggin Street, Birmingham 16.

The temperature-sensitive bimetals, or "Thermometals," produced by The H. A. Wilson Co., Newark, U.S.A., have a reputation for uniformity and reliability in performance. The association of Henry Wiggin and Co. with The H. A. Wilson Co., began in 1937, when Wilco-Wiggin Thermometals were first made available in Great Britain and Europe.

The publication gives the engineering designing thermostatic devices information on the properties of Wilco-Wiggin Thermometals, to help him choose the best grade and size for any particular application.

The Thermometals are produced by firmly bonding together two or more metals or alloys having different expansion coefficients, the composite product being rolled into the form of strip. The effect of a change of temperature on the Thermometal is to produce a change of curvature, which may be utilised in a number of ways, as for example, the deflection of a straight strip, the opening or closing of U-shaped pieces, the rotation of spirals and helices or the dishing of washers and discs.

A Development in Transfer Pressing

A REPORT BY A "USER"

THE problem of rubbing or pressing an under-glaze print firmly on to an earthenware body is one which has long occupied those who are interested in printing on earthenware biscuit. Many ingenious methods have been tried and a few accepted as sufficiently successful to merit their use in the production line.

A Leicester firm of machinery manufacturers approached the problem by handing it over to their research department to whom the art of potting was virgin ground but who were well versed in the application of precision machinery.

In conjunction with practical potters much preliminary work was done and a prototype was put into use and from this developed the first set of six machines which have been installed at four different factories manufacturing earthenware, two of these machines being under the daily observation of the writer.

These six machines have been closely observed and improved and adjusted as experience required, and it can be said that many of the

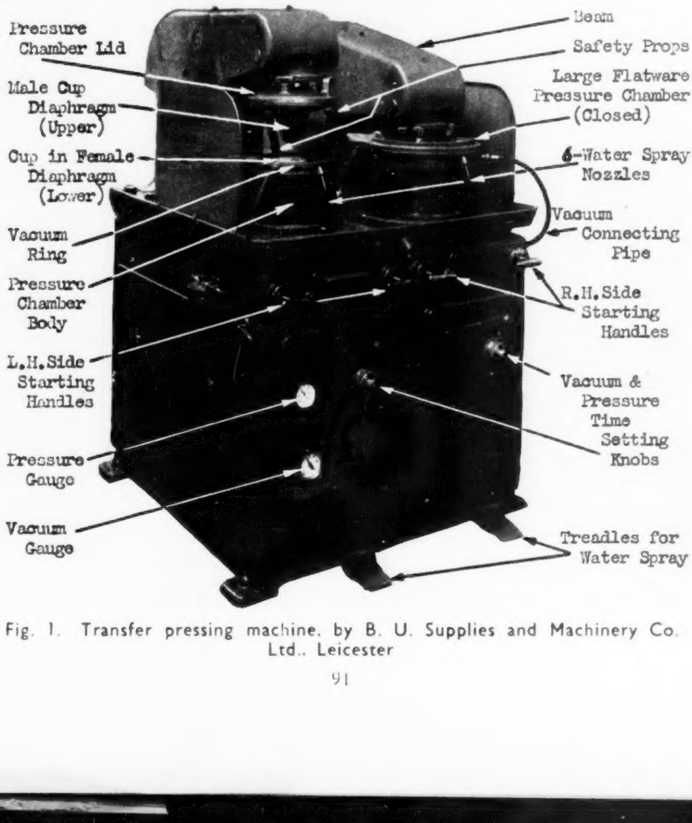


Fig. 1. Transfer pressing machine, by B. U. Supplies and Machinery Co. Ltd., Leicester

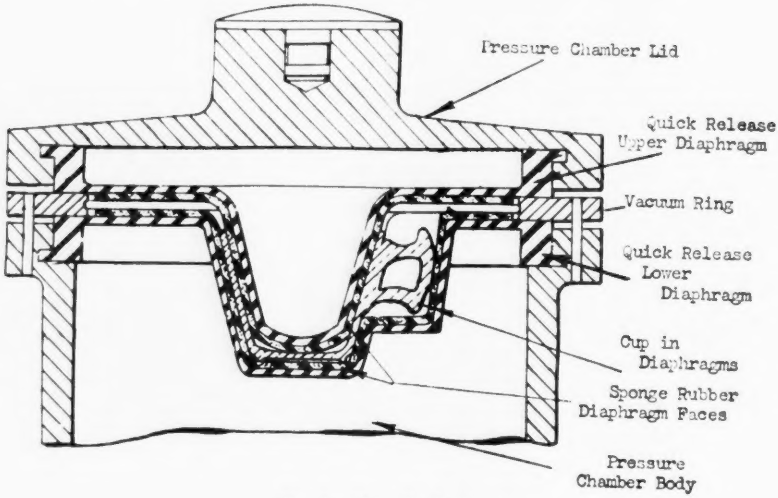


Fig. 2. Cup diaphragms

problems associated with the rubbing process have been overcome.

It should be stated at once that their usefulness is limited to all shapes and sizes of plates, saucers, soups, oatmeals, fruit saucers and similar articles also cups, sugar bowls and similar holloware, it has not been possible to achieve results with spouted articles, nor has it been thought an economic proposition to adjust the machine to deal with large holloware such as cover dish bases, fruit bowls, etc., but there appears to be no technical reason why this should not be done.

The early experiments resulted in the conclusion that in the hand-

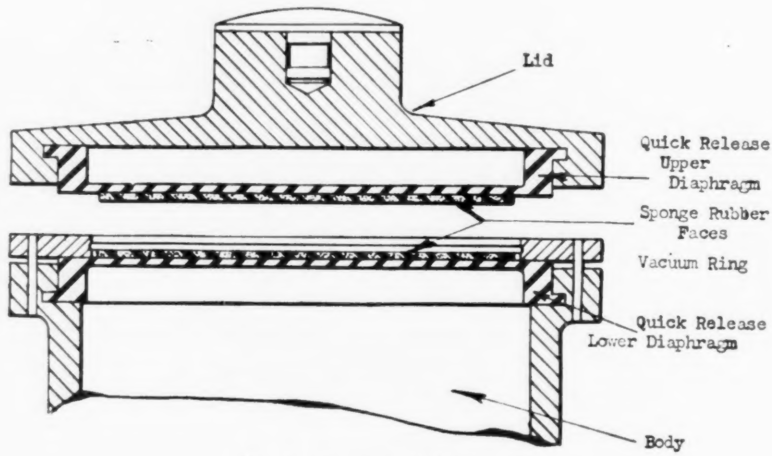


Fig. 3. Flatware diaphragms

Fig. 4. Placing the ware

(Courtesy, W. T. Copeland and Sons Ltd., Stoke-on-Trent)

brushing method, loads of from 20-30 lb. were exerted on a very small area, and it was estimated that the actual pressure required was probably in the region of 100 lb. per sq. in.

Applying pressure of this order to biscuit ware by mechanical means resulted in much breakage, but by equalising the pressure on both sides of the ware this trouble was overcome. In order to obtain this

Fig. 5. Close-up of machine in operation

(Courtesy, W. T. Copeland and Sons Ltd., Stoke-on-Trent)

balance of force the ware was placed between two rubber diaphragms, which, when under the action of pressure readily distorted and took up the shape of the article, the pressure being equally distributed and balanced in all directions, thus making it possible to deal with holloware such as cups, both inside and out, and under and round the handle at the same time.

Sponge Rubber Face on Diaphragms

Experiments showed that some moisture was needed to allow the paper to bed down on to the ware, and production experience showed that varying amounts of moisture are required according to the colour in use. Water does not readily wet the surface of rubber, but by cementing a sponge rubber face to the diaphragms this difficulty was overcome as it held the moisture and actually made possible another line of thought which contributed to the final success of the machine.

In the early trials it was found that light spots kept occurring—usually in the well of a saucer or similar article—it was felt that this might be due to air trapped between the paper and the articles. A vacuum was therefore included to draw out the air from between the diaphragms, the sponge rubber mentioned above allowing the vacuum to act across the diaphragm. This application of vacuum caused the light spots to disappear and results were more consistent. In the author's experience the duration of the vacuum has been found to be more critical than that of the pressure; one second making quite a difference to the finished result.

In the final design automatic timing devices were included which allowed pressure and vacuum times to be independently and readily set between 2 and 8 sec. duration.

The machine itself is a self contained motor driven unit with twin heads in the form of pressure chambers which are made in two halves, each complete with a suitably shaped rubber diaphragm. For flatware a simple flat diaphragm is used, while for cups the lower diaphragm is approximately cup-shaped, the top one being a male unit which roughly fits into the cup when in position. It has been found that a composite shape can be used to cover a range of varying cup shapes. The latest development enables these diaphragms to be changed in half-a-minute or so.

The lower half of the pressure chambers are stationary, but the top section moves vertically up and down at the end of a beam, and in the stop position is raised to give access for the placing of work on the lower diaphragm.

The two heads can be set to operate independently but normally while one is under pressure the other is in the stop position for the removal of the article.

The duration of vacuum and pressure is set by knurled knobs which are pushed in and turned to the required setting, each being marked in seconds.

Safety Devices

A fine spray of water is directed on to the upper and lower diaphragms by three jets and the amount can be controlled by varying pressures on a treadle. After this spray has been used the article is dropped on to the lower diaphragm and two handles on the face of the machine are pulled causing the top half of the pressure chamber to descend and contact the lower half. Should one handle be released the head stops immediately thus making it impossible for the operator's hand to be trapped. Other safety devices are incorporated to prevent the beam from falling from any cause whatsoever.

After the two parts of the pressure chamber are in contact the vacuum is automatically applied and is followed by the pressure after the

pre-set time. As soon as the pressure has operated for the time determined by the setting it is automatically released and the vacuum broken, whereupon the upper half of the chamber automatically returns to the "up" position.

A steel ring with an annular groove is sandwiched between the two rims of the diaphragm and this connects through a hole and a flexible pipe to the vacuum pump. This assists the withdrawal of air.

Air Pressure

The air pressure is equalised between the two halves of the chamber by a connection which is made as they are brought together, thus eliminating the possibility of the diaphragm being expanded prematurely, or of any air pressure remaining when the top section commences to rise as there is free egress to air as the connection is broken.

It is interesting to note that a pressure of 100 lb. per sq. in. applied to an article of 12 in. dia. gives an approximate load of 5 ton. The vacuum used is in the nature of 25 in. of mercury. Both vacuum and pressure readings are recorded on gauges on the face of the machine.

It has been found that two sizes of pressure chambers will cover the normal run of ware which can be dealt with by the machine.

The machines on which these observations are based have been operating at a vacuum/pressure setting of 4/4 sec. which has given a maximum output of 1,400 dozen per normal week per machine. The makers claim that with a correct and steady flow of ware the output should be 2,000 dozen per week at settings lower than those quoted, and that in fact, some work is being done at a 2/2 sec. setting. In fairness to the makers it should be pointed out that the two machines under report are not at the moment laid out for the maximum flow of production and waiting periods have been encountered.

Under ideal conditions no pretreatment whatsoever is required, but—as is common to most automatic ceramic equipment — the machine cannot allow for variations in materials used in the process, and it has been found that with a particular decoration giving perfect results through the machine, when changing to a new boiling of oil, or even a fresh mix of colour, the results may deteriorate, and some catching down of the print is needed. The real answer to this trouble seems to be the development of a synthetic oil which will not deviate from a set standard. The colour mixer's skill can do much to prevent large variations from mix to mix, but natural variations in basic ingredients inevitably occur.

The type of printing oil used, the porosity of the body and depth of the engraving are factors which influence the vacuum/pressure setting needed, in general more difficulty being encountered with light engravings and the more vitreous bodies.

The process is best suited for a continuous delivery of ware by belt or similar method and the economics are a matter for each individual manufacturer to investigate and will vary according to layout and the wages at present paid for rubbing. A layout of cutters and transferers working on a conveyor belt which supplies the machine and thence to a central washing-off position seems to be the ideal.

Finally, acknowledgment is made to The B.U. Supplies and Machinery Co. Ltd., of Law Street, Leicester, for their permission to print much of the material in this article.

Chemical Research Laboratory Appointments.—The Lord President has appointed Mr. D. D. Pratt, O.B.E., Ph.D., acting director of the Chemical Research Laboratory, Teddington, to be director of the laboratory. Sir Robert Robinson, O.M., F.R.S., has accepted the invitation of the Lord President to act as an honorary consultant to the Director, on research in pure organic chemistry.

SATISFIED CUSTOMERS

IT is not often that a man retires and receives a presentation from a host of satisfied customers. When these customers include the names of those listed below, the unusual becomes even more unusual:

Booths and Colcloughs Ltd.
Burgess and Leigh Ltd.
Grimwades Ltd.
W. H. Grindley and Co. Ltd.
James Kent Ltd.
Alfred Meakin (Tunstall) Ltd.
W. R. Midwinter Ltd.
Myott, Son and Co. Ltd.
Pountney and Co. Ltd.
Royal Crown Derby Porcelain Co. Ltd.
Wedgwood and Co. Ltd.
A. J. Wilkinson Ltd.
Worcester Royal Porcelain Co. Ltd.
Sampson Bridgwood and Son Ltd.
Globe Pottery Co. Ltd.
Grindley Hotel Ware Co. Ltd.
Johnson Bros. (Hanley) Ltd.
John Maddock and Sons Ltd.
J. and G. Meakin Ltd.
Mintons Ltd.
R. H. and S. L. Plant Ltd.
A. G. Richardson and Co. Ltd.
Swinnertons Ltd.
Josiah Wedgwood and Sons Ltd.
Wood and Sons Ltd.

It was Mr. Harry Taylor retiring as managing director at the age of 80 from the Universal Transfer Company at Burslem who had this experience.

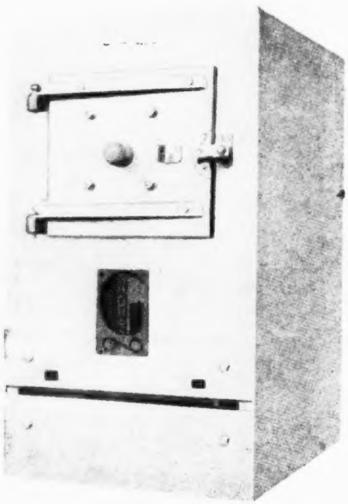
The presentation took the form of an illuminated address expressing the appreciation of Mr. Taylor's services and a television set. The presentation was made at the North Staffordshire Hotel, Stoke, recently.

Mr. Geoffrey Maddock of John Maddock and Sons Ltd., presided, and it was Mr. Harry F. Wood of Wood and Sons Ltd., who handed over the gifts. Both stressed the value of Mr. Taylor's work in the development of ceramic transfers.

The illuminated address stated:

"We, your customers, desire at the time of your retirement as Managing Director of the Universal Transfer Co. Ltd., to place on record our appreciation of your services to us individually, and to the pottery industry in general. We are deeply conscious of your work as a pioneer in the development of ceramic transfers, which has resulted in so much progress, and of your continual and successful endeavours to serve us in respect of quality and design. We hope that you may have many happy years before you, and that the television receiver, which we ask you to accept as a small token of our high esteem and friendship, will add to your happiness."

THE APPLIED HEAT CO. LTD.



The "Grafton" small electric kiln

WE have just received a leaflet describing the "Grafton" small electric kiln manufactured by The Applied Heat Co. Ltd., Elecfurn Works, Watford, Herts. It is designed to reproduce in miniature identical conditions with those found in the larger kilns of the "Grafton" range. The heating element are carried in grooved refractories where they are protected and yet free to radiate maximum heat. Four detachable refractory plates form the floor, walls and roofs of the heating chamber so that in cases of element breakdown replacement is simple.

Working temperatures of 1,250° C. using standard elements or 1,300° C. with special elements can be maintained. All models operate on 190-250 volts A.C. or D.C. supplies, whereas there are optional accessories including a pyrometer or automatic temperature controller.

Further information dealing with these matters can be obtained from the firm.

Collectors seek pieces made by Maude Welch, best known of the Cherokee Indian potters

CHEROKEE INDIAN POTTERY

by

E. CARL SINK

(EXCLUSIVE TO "CERAMICS")

THE Indians had a need and a knack for it, the Sandhillers a glaze and a glory in it, but it took a Yankee and the Piedmontese North Carolinians to get a pretty penny, or more, from it. Today the modern pottery factory of H. Leslie Moody, an Ohioan, is turning out as much ceramic production as all the rest of them put together, utilising the native clays, native art forms and native skills he found when he decided to settle in the foothills of the Brushy Mountains, North Carolina, U.S.A. His operation is merely the industrial climax of 400 years of handicraft experience.

DeSoto and his men ate from Cherokee Indian pottery in the Great Smokies, and the Indians still make the same bowls and jugs—without benefit of a wheel. The pieces are built up laboriously by hand, one rolled coil of clay after another, then tossed directly on to hot coals for curing, the process resulting in the

crude but attractive burnt pattern. Maude Welch, best known of the Cherokee potters, still makes a piece now and then, though she complains that constant working in the wet clay has given her a misery in her arm. The traditional Cherokee is not glazed.

Nearby is the unique Pisgah Forest Pottery, which has evolved porcelain decoration rarely achieved in the United States. Its work often lands up as collectors' items. In the Sandhills, two hundred miles to the east, the pottery art of earliest settlers is carried on by both Jugtown, near Hemp, and the Coles, of Sanford. Both native forms and Chinese designs are turned out on the wheels. At Jugtown there is a stern injunction against any modern innovations—even the clay is mixed by mule power, the mule pulling a sweep around which in turn operates the mixing paddles. Similar enterprises are scattered over the State.

Into this welter of pottery-making traditions, and into the largest ceramic-material producing state in the Union, ventured Leslie Moody. He had investigated the nearby deposits of kaolin and feldspar and the ball clay deposits along the Tennessee-Kentucky border. Hickory business men took a look at his prospects, within ten days put £50,000 into his £125,000 kitty to create Hyalin Porcelain, Inc.

By 1st May, 1947, he began turning out a complete line of porcelain art pieces, decorative accessories and china specialities, a line which has become immediately popular.

Decorating, by handpainting, at the Hyalin Potteries

Piedmontese labour must have a knack for it too, for it took to it easily. Eighty per cent. of work is strictly handwork, but much of the production comes from moulds instead of from the traditional wheel.

Moody himself believes that American industry eventually will take over the chinaware market now dominated by English import. And the success of his own enterprise in the Brushy foothills seems to be a step in that direction.

DRYING IN THE POTTERY INDUSTRY*

by

S. R. HIND, B.Sc., A.R.C.S., F.R.I.C.

PART II

WHILST the design of ceramic dryers is governed by the economic and scientific factors referred to in Part I (CERAMICS, March, 1951) the engineer must take other factors into consideration. The use of the tunnel kiln for firing is becoming well nigh universal, and whilst it provides higher thermal efficiency it also makes a large quantity of heat available as waste hot air and serves to raise the general ambient temperature of the factory by its conduction and radiation losses. Consequently, especially in sanitary ware manufacture, where much of the drying is closely associated with craftsmanship and open shop drying is required on a large scale, there is so much advantage in building the factory above and around the tunnel kilns that it may come to be entirely dependent on them as a source of heat for drying purposes.

Waste Heat from Power Units and Electricity Generators

In other cases, particularly in pottery manufacture, there is a marked tendency towards the factory generating its own electricity on a large scale and utilising either (a) large volumes of low pressure exhaust steam or (b) hot water, as the primary source of heat for drying.

Before a survey is made of the main types of dryer used for the actual ware it is necessary to mention dryers for press clay which is in process of conversion to damp dust for wall and floor tile and electrical porcelain production. Here no care

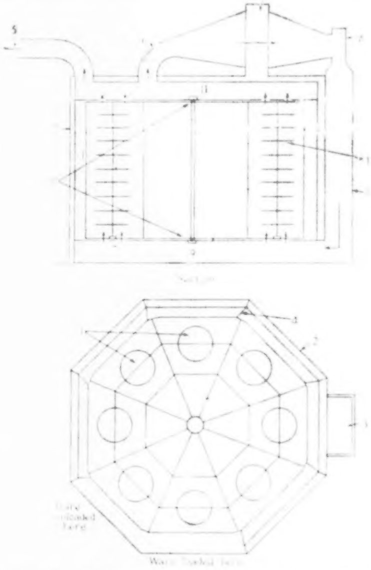


Fig. 5. Diagrammatic layout of potters' stove

1. Ware trays. 2. Outer casing. 3. Hot air duct. 4. Rubber sealing strip. 5. Discharged air to atmosphere. 6. Damper control of fresh air. 7. Steam unit heater. 8. Fan. 9. Hot air distribution chamber. 10. Inner pivoted frame. 11. Discharged air collection chamber

* This paper has been contributed, at the invitation of The Institute of Fuel, to a symposium under the general heading "A Study of Drying," which is being conducted during the 1950-51 Sessions.

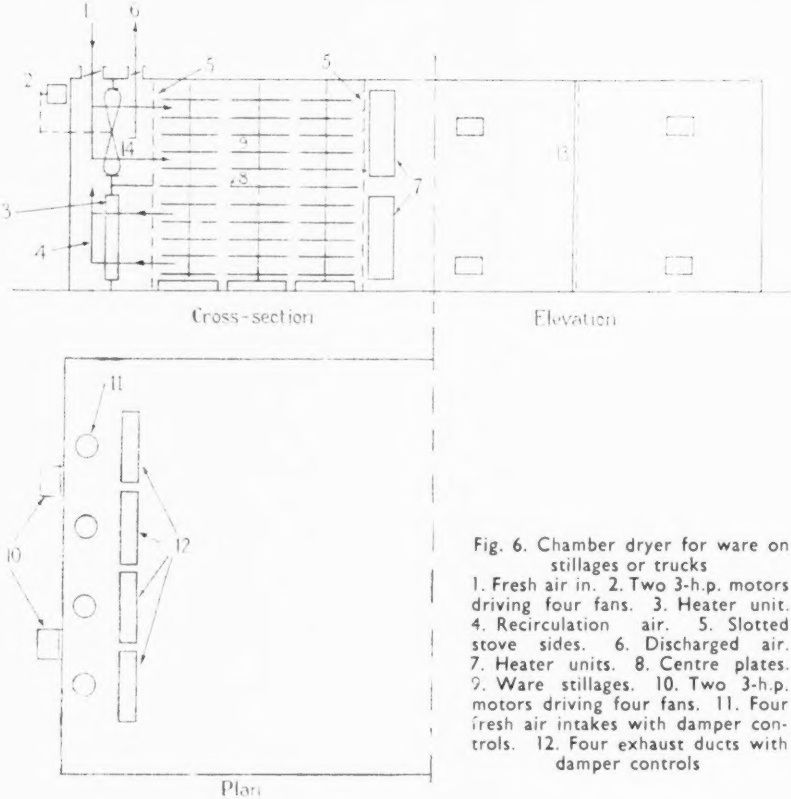


Fig. 6. Chamber dryer for ware on stillages or trucks
1. Fresh air in. 2. Two 3-h.p. motors driving four fans. 3. Heater unit. 4. Recirculation air. 5. Slotted stove sides. 6. Discharged air. 7. Heater units. 8. Centre plates. 9. Ware stillages. 10. Two 3-h.p. motors driving four fans. 11. Four fresh air intakes with damper controls. 12. Four exhaust ducts with damper controls

in preserving the exact form of the material during drying is necessary, but care must be exercised to prevent temperatures over 200° C. being attained, destroying some of the plastic quality of the material; also certain kinds of contamination must be avoided. Usually tunnel oven exhaust gases or, alternatively, hot air from the cooling zone is employed in enclosed tunnels fed with the clay on trucks. Speed of operation and control of final moisture content make it advantageous to extrude the press clay in small pieces which may be dried on trucks or travelling belts, but this practice is by no means universal as yet. Another method is to dry the original slip directly to a suitable moisture content on a heated drum. This avoids a great deal of labour, but of course uses far more energy than a filter press in achieving the main stage of dewatering. Whether this is the more economical procedure must depend partly on local conditions and no clear verdict appears to be available as yet.

Formed Articles (General Considerations)

Dryers for formed ware are mainly concerned with removing water after initial forming of the article in a plaster mould or a steel die, prior to biscuit firing; while a second group is concerned with removing a small percentage of water acquired in the course of glazing. Varied as the

different cases are which fall under this general heading they are all, for the engineer, dominated by the time factor.

Take, for instance, table flat ware being produced at a rate of 6 articles per min. The necessary drying time may be $2\frac{1}{2}$ hr., and consequently $2\frac{1}{2} \times 60 \times 6$ (= 900) articles at least must be accommodated in the dryer attached to the making machine. Only by reducing the making rate or the drying time can this accommodation be reduced successfully. The former would be economically unsound, whilst the latter is the object of research and improved design. Thus all the dryers in this class accommodate many articles, in many cases in or on moulds, each presented to the source of heat so that it shall have the most favourable opportunity of being dried as fast as every other, and uniformly if possible. Such a dryer involves a carefully designed system of supports. Moreover, these must be designed so that the labour of obtaining access to each tray or carrier is minimised whilst the machine is not made too large, complicated, costly or thermally inefficient.

Jiggered Flat Ware (Modernised Dobbins)

Fig. 5 shows a type of dryer which has found most favour with English potters in recent years. Hot air is provided by the exhaust steam fan-driven heat exchanger on the top of the machine. The air is driven down the duct on the left hand side to a space under the ware and distributed to its various sections, except two, namely that being fed by the maker and that from which the dried plates are being removed for towing. The eight sections are rotated by hand on a central spindle. Each section is provided with its own rotatable set of shelves, furnished with the necessary moulds. Air,

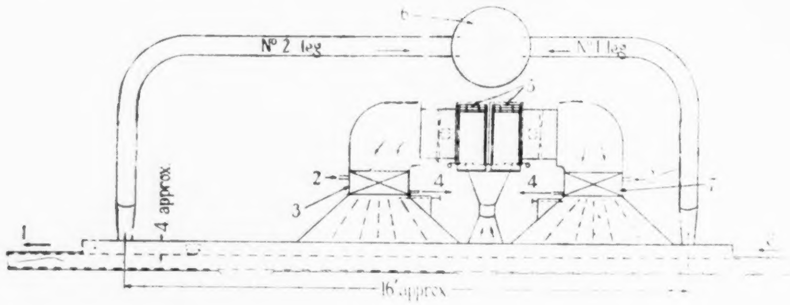


Fig. 7. Conveyor belt dryer for handled cups
1. Ware discharge. 2. Steam. 3. No. 2 heater. 4. Condensate: 5. Fresh air inlets. 6. Main exhaust duct. 7. No. 1 heater. 8. Loading end

after passing upwards amongst the drying ware, is returned for reheating and recirculation—except for a controlled amount which is exhausted and replaced. The dryer is insulated, and baffles prevent hot air from the drying sections blowing out into the shop.

As has been indicated above, the size of a potters' stove or dryer depends to a large extent on the output of the making machine. As such machines are now being developed for larger and larger rates of production the dryer is coming to occupy a correspondingly larger amount of floor space, and the problem of merely reaching the appointed place in the dryer with each piece as it is made becomes serious. Also, delivery points in a shop filled with such machines may become separated by large enough distances and involve such quantities of ware as to become inconvenient from the point of view of transport and layout. This is the more acute if the design of the dryer involves lines of

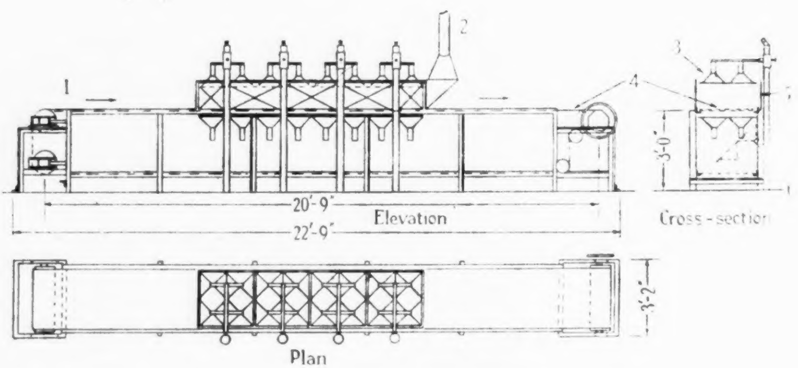


Fig. 8. Conveyor belt dryer for glaze dipped china
1. Loading end. 2. Ventilation hood. 3. Adjustable radiant heat dull emitters with reflectors, 3 in. to 12 in. from conveyor. 4. Wire mesh conveyor. 5. Removal side plates, nickel plated internally. 6. Floor level

TABLE 3. TYPES OF DRYER USED IN THE CERAMIC INDUSTRY

Type of dryer	*Material or ware normally treated*	*Process of production*	*Source of heat*	*Method of application of heat*	*Method of moving ware*	*Time of drying (approx.)*	*Max. temp. (approx.), F.*	*Origin*
Waste heat tunnel	Press clay	Drying for dust	Tunnel kiln waste heat	Direct or via heat exchanger	On light metal trucks	16 hr.	167	Bricesco
	Tiles in saggars	Drying before biscuit fire			On tunnel kiln cars	51 hr.		
Tunnel	Tiles on bats	Drying before biscuit fire	Exhaust or live steam	Fan driven air with recirculation control	Three lines of 14 trucks	24-36 hr.	—	Mitchell
Walk-in stove 1	Tiles in bungs	Drying out	Exhaust or live steam pipes	Pipes below racks	Manual, on boards	2-7 days	120	
2	Insulator blanks	Hardening for turning	Hot clean air from kilns or special stoves	Distributing ducts at high level (sometimes fitted with recirculating fans)				
3	Plaster moulds	Initial and service drying (weekends).						
Potters' dobbin (old type)	Clayware in moulds	Between maker and tower	Live steam pipes below ware	Natural convection	Manual rotation, work on boards	24 hr.	120	Boulton
Potters' stove (new type)	Clayware in moulds (chiefly flat ware)	Between maker and tower	Exhaust steam in heat exchanger	Fan driven circulation with recirculation control	Manual rotation, placed one at a time	2-3 hr.	160	Boulton
Chamber dryers (Carrier and similar types)	Turned insulators	Between turning and clay glazing	Exhaust steam in heat exchanger	Fan driven circulation with recirculation control	On movable stillages, wheeled or lifting units	40 hr.	190	Mitchell
	Plaster moulds (pottery)	Initial drying				2-6 hr.	160	
Rotating table 1. Multiple	Cups in moulds	Between maker and sponger	Hot air from exhaust steam pipes	A jet into each mould	Manual rotation	20 min.	160	Bloore patent
2. Single	Cups in moulds	Between maker and sponger	Hot air from exhaust steam pipes	Downward hot air blast	Manual rotation	15 min.	155	Unsworth
Conveyor belt 1	Cups after handling	Final drying	Hot air from exhaust steam pipes	Downward hot air blast, recirculated	Motor-driven	30 min.	170	Victoria
2	Dipped china, special assortment	Before china glost fire	Electricity	Radiants above and below belt	Motor-driven	15 min.	—	Chandos
3	Small flat and cups	Glaze drying	Gas (or electricity)	Radiants and fan	Motor-driven	3-4 min.	—	Mitchell
Chain conveyor ("Mangles") 1	Glaze dipped ware	Drying after dipping	Live steam pipes	Radiation and natural convection	Motor-driven	16 hr.	220	
2	Glaze dipped ware (up to 8 in. flat)	Drying after dipping	Exhaust steam pipes	Fan circulation and recirculation, with blast into ware if required	Motor-driven	15 min.	140	Mitchell
3	Flat and h'ware in moulds	Initial drying	Exhaust steam pipes or (direct) Town's gas	Fan circulation and recirculation, with blast into ware if required	Motor-driven	Cups 20 min.	170	Service (Engrs.), Mitchell, Williams-Gardner, Boulton Hopol

communication for both feeding and delivery opposing one another in the same gangways.

Mangles

Consequently there is arising an increasing interest in, and use of, a type of dryer which is mechanically driven and which presents a constant supply of fresh moulds within easy reach of the potter and of dried ware equally accessible to the tower* on a different gangway. The conveyor mechanism in such dryers is based on that of the old potters' mangle, originally the standard dryer for glazed dipped ware. This consisted of a pair of chain cog wheels on a shaft at the top of the tower† and a similar pair at the bottom; the top shaft was driven off a belt or motor and reduction gear. The chains carried trays slung between them on which the ware was suitably accommodated. Heat was supplied by a bank of steam pipes between the rising and falling trays, air was admitted at the base (where loading and unloading occurred on opposite sides) and was exhausted at the top. By substituting forced and directed circulation with humidity control with mechanical improvements, the original pattern was greatly improved, but the growing rate of input when applied to clay ware, coupled with its appropriate time cycle, made these machines difficult to accommodate. Rather than construct a high tower for such a machine it is now the practice to fold it on itself into a serpentine form which can be accommodated in the ordinary workshop. The well-known Procter and Schwartz dryer is of this type and the principles involved are applied in many modern designs. A difficulty which requires the greatest care in design with these low type mangles is that they are liable to release hot air into the shop.

* She who "tows" or smooths the dry ware with tow or similar material.
† Tall building.

General

Table 3 is designed to afford a general idea of the different types of dryer in use in the industry and the great variety of purposes for which they are required. Figs. 6 to 9 illustrate some of these in service.

Holloware

Apart from the necessity of removing cups from their moulds whilst still moist enough for the sticking on of handles, cups and other holloware have peculiarities which become very noticeable as soon as intensified drying is attempted. In the clay state the only surface unprotected by the mould is inside. Intensification of drying rate of the

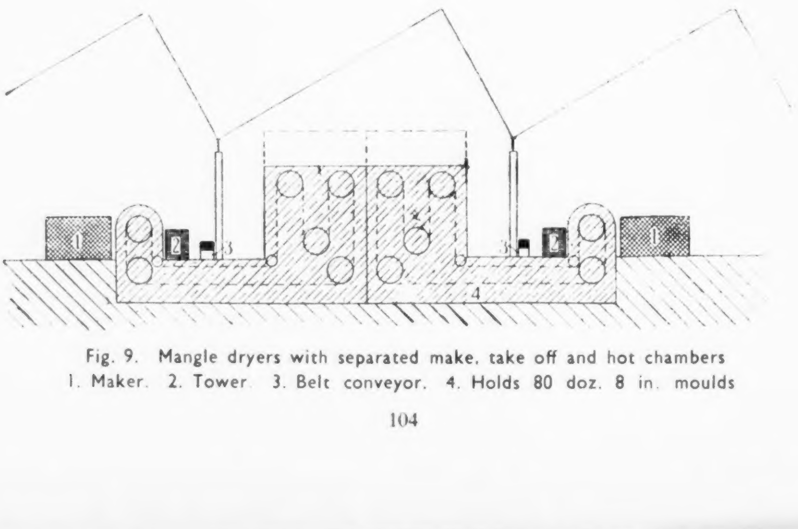


Fig. 9. Mangle dryers with separated make, take off and hot chambers
1. Maker. 2. Tower. 3. Belt conveyor. 4. Holds 80 doz. 8 in. moulds

mould is the principal result of raising the temperature and increasing the air circulation. This results in holloware with dry edges and too wet bottoms, and in some risk of mould burning. Such a result is worthless and sets a limit to the drying rate. Eventually it was found that warm air blown into the middle of each article gave excellent and rapid drying, principally from the inside, whilst the spill-over air bathed the outside plaster surfaces, and kept them in working condition. This principle was embodied in the Bloore cup dryer and has since been applied in a number of other units. Such dryers are usually surprisingly small, compact and inexpensive. The very uniform results commonly attained have favoured large outputs with low losses on a belt assembly plan incorporating sponging, handle sticking, final drying, saggaring and final clay inspection.

In the drying of glaze dipped jugs, tea and coffee pots and sanitary earthenware w.c. pans, intensification of heat application by radiant heat from outside was tried. This resulted in heavy condensation of steam on parts of the inside, with a subsequent run down of condensate which displaced the glaze. The trouble was completely eliminated, and successful rapid drying obtained by blowing hot air downwards into the articles as they slowly travelled through the dryer.

Acknowledgments

The author's best thanks are due to William Boulton Ltd., Service (Engineers) Ltd., L. A. Mitchell Ltd., Doulton and Co. Ltd., and the Ministry of Fuel and Power (Fuel Efficiency Branch) for assistance in providing certain illustrations and in collecting some of the data for Table 3.

The British Ceramic Research Association

REPORT FOR 1949-50

WORK is in progress on the building of a new research station, which will provide increased laboratory accommodation and also facilities for meetings of members. It is also proposed to erect a further building, equipped with pilot-scale plant and facilities for making and firing ceramic products, for development work.

The following summary gives the progress made in some of the more important items of work during the year.

Pottery

A survey is being made of the characteristics of the highly plastic Devon and Dorset ball clays, which are used in the domestic pottery industry. Particular attention is being paid to the effect of long periods of weathering. In the course of the work, attention has been drawn to the need for a better knowledge of the nature of the organic matter present in clays, and methods of determining this are being explored. Similar studies are being made in connection with the fireclays used in the manufacture of tiles and sanitary ware, and a small group of clays used in the teapot industry. A study of the effect of various methods of preparation on the behaviour of bone in the china body is also being made.

The fundamental nature of the casting process continues to be studied on a laboratory scale. Factors affecting casting rate have also been investigated on a works scale, and methods of eliminating day-to-day variations examined. A considerable study has been made of methods of measuring the fluid properties of slips which have, of course, an important effect on casting. The clay-making process has been studied with a view to reducing strains during working which give rise to undesirable features, such as loss of shape, in the finished article.

The efficiency and performance of all the types of dryers at present in use have been assessed, and on the basis of this work a large-scale experimental dryer has been built. Different methods of drying have been examined, and the economic relationship of different sources of heat has been studied. In order to examine the changes taking place during drying a laboratory dryer has been built capable of holding a large quantity of ware and of maintaining controlled conditions as regards temperature, humidity and rate of air flow. A feature of this apparatus is that it provides for the independent variation of temperature and humidity.

In many sections of the pottery industry, the properties of the finished product are being investigated in some detail. The factors influencing the fired strength are being studied with a view to developing bodies with improved characteristics in this respect. The crystalline phases occurring in bone china and the relationship between the structure of the body and the translucency are being examined. Both are being considered as functions of the firing treatment. The texture of the earthenware body is being examined by several methods.

A number of tentative testing standards have been drawn up based on developments which have taken place in recent years. The use of these should make for more reliable comparison between the results obtained from different laboratories.

Refractory Materials and Heavy Clay Products

During the year under review several aspects of the durability of

blast furnace refractories have been under investigation. One of the most serious of the causes limiting the useful life of the blast furnace is the disruption caused by the growth of carbon around the ferruginous spots in the firebrick lining of the stack, although all such spots in firebricks are not equally effective in promoting the reaction. The Association has made a study of the processes by which inactive iron spots may be activated. The occurrence of depositions of carbon and of zinc compounds together, which is sometimes found within blast furnace stacks on dismantling, may be significant. Other work of the Association on blast furnace linings has concerned attack by lime and alkalis and the conditions for the formation of the various potassium aluminium silicates and calcium aluminates. Experimental and works studies of blast furnace tap-hole clays have also been carried out.

Spinel Group of Minerals

During the past year a study has been commenced of the electrical conductivity of the spinel group of minerals with a view to throwing further light on their structure and constitution. This is of importance for steel production because of the tendency of chrome and chrome-magnesite products (which contain spinels) to expand and burst in contact with magnetite (another spinel) in basic steel furnaces. Knowledge of the spinel minerals has also been extended by synthesizing the magnesium, ferrous, manganous and zinc vanadites and measuring the relevant properties. The study of the system alumina-ferric oxide-ferrous oxide has yielded important information on the stability of certain spinels of interest in the technology of steel-furnace refractories.

The durability of the silica brick roofs of basic and acid electric arc furnaces has been under investigation. This has led to investigations of the rates of conversion of the different forms of crystalline silica in the presence of each of the three oxides of iron at 1,300°-1,400° C. and at 1,500°-1,600° C. The effects of the oxides of aluminium, calcium, sodium and potassium on the conversion of quartz have also been examined.

Retort Refractories

The deterioration of gas retort refractories in service has been studied both in the works and in the laboratory. Surveys have been made at six-monthly intervals since 1945 of an intermittent vertical chamber retort setting to detect movement relative to an external datum and to correlate it with the development of leaks and cracks in the retorts. By means of thermocouples continuous records have been taken of the temperatures in various positions in the walls of two typical continuous vertical retorts. Hitherto data of this kind have not been available to help to assess the durability of the refractories in relation to the conditions of retort operation. A comparative study of French and British practice in relation to the use of silica refractories in gas retorts has been undertaken.

Much of the work hitherto carried out on the development of refractory insulating materials has been directed towards devising suitable methods of testing the thermal conductivity and shrinkage of these materials at high temperatures A further conductivity apparatus has now been devised which enables the measurement of conductivity to be made at higher average temperatures. High temperature shrinkage measurements have been made on typical materials heated for various periods, both for test-pieces uniformly heated and for those heated from one face only. The information obtained on materials uniformly heated for short periods may not be applicable to long-period-heating from one face, which approximates more nearly to the conditions met with in practice.

The survey of the important building brick clays of the country, mentioned in last year's report, has continued. The mineralogical analysis of the various fractions is being undertaken.

Engineering

Following the assessments of the performance of a number of machines recently introduced into the industry, the engineering section has now

turned its attention to the development of new equipment. An interlocking safety device developed to guard the moving parts of tile presses without interfering with the rate of production has given satisfactory service in a factory for several months. Further work has been done on the development of a machine for lining plates either with gold or with other colours. Designs are being considered for a system of sizing, sorting and packing tiles automatically. Following the recent introduction of new Factory Health Regulations, a study is being made of the possible methods of cleaning the floors of pottery-making shops. The experimental extrusion machine has been used for further experiments on different clays in a programme designed to give information of a fundamental nature concerning the flow of clay under pressure through an orifice.

Fuel and Kilns

In the firing of heavy clay products the fuel consumed represents a substantial proportion of the manufacturing costs, and the efficiency of the firing operation is therefore very important both from the national standpoint and that of the industry. With a view to increasing the efficiency of firing practices throughout the industry, the Association is collecting data on kilns of different types used for firing various classes of goods. Tests have been made on the comparative efficiency of typical kilns used in the roofing tile industry, and the effects of modifications to the kilns on their methods of operation have been assessed. Similar work is now in progress for brick kilns. The thermal efficiency tests carried out have laid the basis for studies on the utilisation of waste heat especially from intermittent kilns. Work on the reduction of emissions of smoke from kilns, which was discontinued during the war, has been resumed.

On the pottery side, a comprehensive study has been made of all types of kilns firing decorated ware, and tests have been made on several other kilns for biscuit and glost ware. Statistics have been collected from many factories on the effect of such factors as size, temperature and rate of throughput on efficiency. In addition, it has been possible to run a full-size factory kiln under intentionally different conditions, and thus measure directly the variations resulting from certain specified changes. A provisional patent has been lodged covering a new method of draught control designed to reduce the disturbance caused by the opening of kiln entrance doors.

Information and Liaison Services

The work of the liaison section, particularly for the pottery industry, has been expanded considerably during the year. Regular visits are paid to members whether any specific request has been received or not. Several hundred requests a year are received for help in connection with immediate manufacturing difficulties, and these frequently entail additional visits. Groups of members in a particular section are addressed from time to time, and thus kept informed of the work which is being done on behalf of their section. During the winter months, lectures are given and are frequently attended by over 250 representatives of member firms.

The British Ceramic Research Association, chairman, Col. H. Johnson, D.S.O., T.D., J.P., D.L., and director, A. T. Green, O.B.E., D.Sc., F.R.I.C., F. Inst.P., M.I.Chem.E., have laboratories at the following:

1. "Beechfield," Queen's Road, Penkhull, Stoke-on-Trent. (This is also the Association's office address.)
2. Mellor Laboratories, Shelton, Stoke-on-Trent.

TRADE LITERATURE

CELLACTITE & BRITISH URALITE LTD., of Cellactite Works, Whitehall Place, Gravesend, Kent, will be pleased to send samples and information on the following products—Kimolo (Moler) Hollow Partition Blocks, Kimolo (Moler) Insulating Blocks largely to keep flue walls cool and prevent condensation, staining and flaking of decoration, as well as a technical handbook on Kimolo Insulating Bricks to those interested.

Likewise the Hammill Brick Co. Ltd., Estuary, Sandwich, Kent, will send samples of their H.B. Harvest Brown Sand-faced Bricks and a brochure describing their products.

NEW CLUB FOR POTTERY INDUSTRY

DESIGNED to cater for all those directly or indirectly connected with the ceramic industry, the British Pottery Manufacturers' Federation Club in Federation House, Stoke-on-Trent, which was opened on the 3rd April, will fill a long felt need, particularly for the entertainment of overseas buyers and agents.

The idea of establishing Federation House as an administrative and social centre for members of the pottery industry was conceived by the late Mr. Sidney H. Dodd, when he was Director of the Federation, in conjunction with Colonel Harry Johnson, D.S.O., Chairman of the Potters' Insurance Company, Ltd.

The club was formally opened by the President of the Federation (Colonel W. J. Kent, C.B.E., D.L.), and the principal guest at the ceremony was Sir Cecil Weir, K.B.E., M.C., D.L., Chairman of the Dollar Exports Board.

Accommodation Available

Accommodation available consists of a restaurant seating 100, a lounge, and a private dining-room capable of accommodating parties of twenty members. The bar is attractively panelled and has an unusual padded leather counter.

The premises comprise the two top stories of Federation House, which have been converted by Wood, Goldstraw and Yorath, the Federation architects. The furniture has been specially designed in pink beech wood by Mr. Gordon Russell, of the Council of Industrial Design.

Honorary Members

To overseas buyers and agents, the Trustee Management Committee of the club are extending temporary honorary membership.

Subscription rates vary for town and country members. Town members will pay £15 15s. a year and country members £7 17s. 6d. An entrance fee of £10 10s. is payable in addition to the subscriptions.

The restaurant service is being undertaken on contract by Peter Merchant Ltd., and *à la carte* luncheons and dinners will be served.

High Temperature Insulating Materials*

Their Properties and Testing

by J. F. CLEMENTS, B.Sc., A.R.I.C.
(British Ceramic Research Association)

PART 2

Mechanical Properties

THE determination of crushing strength at room temperature calls for little comment. Any standard testing machine may be used, but the rate of loading must be specified, and in some cases the maximum rate of strain also. In measurements of crushing strength at the British Ceramic Research Association the rate of loading is not allowed to exceed 200 lb. per sq. in. per. min., or the rate of strain 0·05 in. per min. The maximum rate of strain is specified, since some bricks suffer a slow progressive collapse as the pressure is applied. This type of brick is deemed to have collapsed when it has been compressed 10 per cent. linearly.

Whole bricks or half bricks must be used. It has been shown[1] that smaller specimens such as 1 in. cubes may give values some 20 per cent. lower than those obtained with half bricks.

It is essential to interpose some soft packing material such as millboard or fibre board between the specimen and the platens of the machine.

Refractory Properties

(*a*) *Shrinkage on Reheating.*—In the refractories industry no test features more prominently than the determination of the permanent linear change on reheating. The procedure is standardised[2] for all types of refractory product, and only the testing temperature is varied to suit the material. Two or more test pieces 2 to 3 in. high and 2 × 2 in. in cross-section are cut from the brick and the 2 × 2 in. faces are ground smooth and parallel so that their distance apart can be measured with broad edged vernier calipers, or other suitable gauge. They are heated at 5° to 6° C. per min. in a suitable furnace, avoiding reducing conditions, to the selected temperature, which is maintained for 2 hr. The pieces are remeasured when cold and the change in length reported as a percentage of the original length.

In the case of high temperature insulating materials the reheat test is carried out at a number of temperatures separated by intervals of 50° C., and the shrinkage characteristics of the material are assessed from the assembled results. In effect these figures, obtained in a test of 2 hr. duration, have to be used to decide whether a brick will shrink excessively at a particular temperature over a very long period of time. There is no difficulty in making this

* This paper was produced for a conference on Heat Insulation, under the auspices of the Joint Committee on Materials and their Testing, in conjunction with The Institution of Gas Engineers, on 30th November, 1950, at The Institution of Mechanical Engineers, Storey's Gate, London, S.W.1.

decision with some bricks, notably the diatomite materials, where a 50° C. rise in testing temperature may bring about a sharp and decisive increase in shrinkage. Most of the clay bricks, however, give at successive temperatures a steadily rising series of shrinkage figures with no sudden changes. This type of data can only be interpreted in the light of experience or with the aid of empirical rules. Thus L. R. Barrett suggests[3] that hot face insulating bricks can be recommended for general use to within 100° C. of the temperature at which 1·0 per cent. linear shrinkage occurs in 2 hr. in the laboratory reheat test. The author is of the opinion that this rule may be rather severe when applied to some bricks, and that the above figure can often be reduced to 50° C. Recent work[1] has thrown doubt on the value of all empirical rules of this type. In the first place, the 2 hr. reheat test has been shown to give a very inadequate picture of the shrinkage that is likely to occur over long periods. When applied to a number of bricks it fails to place them in the order into which they would fall, as regards shrinkage, during service. In this connection it is noteworthy that a testing period of 24 hr. is specified in the U.S.A.

New Test Required

Such confidence as the reheat test enjoyed has been further reduced by the discovery that the behaviour of insulating bricks in a furnace wall, where they are heated on one face only, differs radically from their behaviour in the ordinary reheat test, where the specimens are heated uniformly throughout their bulk. The temperature gradient within the wall may actually cause the heated face to increase in size at a temperature which produces appreciable shrinkage in the ordinary test. There is also a distinct difference between the length change occurring along the 9 in. axis of the heated face of the brick and that measured across the 3 in. axis. If service conditions and testing procedure produce such widely different effects, some test more closely approaching furnace practice must be sought. A test in which a panel of bricks is heated from one side, as in the A.S.T.M. spalling test,[5] would appear to meet the need, were it not for the difficulty of evaluating the result. Stresses developed in the heated face produce the length increases previously mentioned, and if they become excessive the face cracks. These cracks do not necessarily put the brick out of commission, nor do they always reduce its efficiency appreciably. The fundamental difficulty of a panel test would, therefore, lie in deciding what constitutes a destructive amount of shrinkage. General agreement on this point cannot be expected.

The shrinkage-on-reheating test as at present carried out appears to be deficient in several respects. It is important, however, that the importance of these deficiences should not be exaggerated. A good conservative estimate of the capabilities of an insulating brick can still be obtained by applying the old empirical rules. The work described above has merely shown that in doing so many bricks may not be fully exploited.

(*b*) *Refractoriness-under-load.*—It is not proposed to describe this test in detail. A full account of the apparatus can be found elsewhere[6]. High temperature insulating bricks are usually tested under a constant load of 10 lb. per sq. in. at a temperature that is maintained constant for a fixed period, or until the specimen collapses, whichever is the shorter time. The result is reported either as the number of minutes elapsing between the attainment of the testing temperature and the failure of the specimen, or as the percentage length change in the period of the test.

(*c*) *Spalling Resistance.*—Resistance to thermal shock (i.e., to rapid temperature change), can be measured

in a number of ways. L. R. Barrett, W. F. Ford and A. T. Green have described a detailed investigation of three tests whereby the spalling resistance of insulating bricks can be evaluated.[3] In the first, test pieces measuring $3 \times 2 \times 2$ in. are placed in a furnace that has been heated to 1,000° C. After 10 min. they are removed and allowed to cool on a brick floor for 10 min., then replaced in the furnace for a further 10 min., and so on. This is repeated until the specimens can be readily pulled apart. The number of cycles required to promote fracture is reported (a cycle consists of one heating and one cooling treatment). It is also customary to note the cycle at which cracks first appear, but this can rarely be ascertained with any precision.

Two Weak Points

There are two weak points in this test. In the first place, one person may pull a given specimen apart more readily than another, and although no dictionary allows the word "pull" to be synonymous with "rend" or "rive," in practice the distinction may be lost. In the second place, the test lays too much emphasis on the transverse crack, which, as we shall see, is not considered an adequate criterion of failure.

An alternative test is known as the "miniature panel test." Here a brick of standard size is heated, on one face only, to 1,000° C. in the space of 30 min., then removed from the furnace and cooled by an electric fan for 30 min. The criterion of failure in this test is the loss of 5 per cent. of the original weight from the hot face, or division into two pieces by a transverse crack.

The third test investigated by Barrett, Ford and Green was similar to the panel test employed as a standard method by the American Society for Testing Materials.[5] The modified procedure described by W. R. Kerr[6] was followed. Two piers of five bricks form a panel 15×18 in., which is heated uniformly over its surface, then cooled by an air blast from a fan delivering 1,400 c. ft. of air per min. The performance of the test bricks is judged from the loss of weight from the exposed faces after a fixed number of cycles. Kerr is disposed to neglect transverse cracks dividing a brick into two pieces, for, as he points out, such cracks would have little effect on the brick's performance or on its life in a furnace wall. An important feature of the panel spalling test in American practice is the preliminary preheating treatment, which often sharply reduces the spalling resistance of the material and makes the test more closely simulative of service conditions.

The Subjective Element

The panel spalling test is not free from the subjective element, since the spalled pieces must be dislodged "with gentle force." Many insulating bricks are puzzling subjects for this treatment, for the spalled pieces are firmly interlocked, and two operators will often differ in their opinion of what constitutes a loose fragment.

Barrett, Ford and Green found that all three tests described above placed a group of bricks in the same order. On examining the individual results, however, some doubt arises as to whether the tests are sufficiently conclusive to place the bricks in any order at all. The figures given by individual specimens taken from the same brick, and by single bricks from the same batch, are astonishingly variable. Some impression of the spread of the results can be gained by calculating the Pearson coefficient of variation for each group of results. This is given by

$$\text{coefficient of variation} = \frac{\text{standard deviation}}{\text{mean}} \times 100$$

In the small prism test the coefficient ranges from 30 to 100; in the miniature panel test values up to 46 are found, while the large panel test

gives one or two low values and several very high ones ranging from 50 to 90. These figures should be compared with equivalent values obtained in the measurement of crushing strength, which is a notoriously variable property. The coefficient of variation in the crushing strength of a typical insulating brick was found to be 11; a firebrick gave 25, and a silica brick 24.

To obtain a representative figure for the spalling resistance, therefore, a large number of tests are required. Even in the large panel test, which gives rather less variable results than the others, if the average of all the results is to be relied upon within 1 per cent. (at a statistical level of significance of 0·1) some 60 bricks must be tested. Such numbers would be out of the question in practical testing.

Exaggerated Picture

The laboratory spalling test is also open to another criticism, in that it introduces an element that is not present under service conditions. In the laboratory, the work of the thermal treatment is completed by the application of a force to remove the spalled pieces. Under normal operating conditions these pieces would remain undisturbed, and there is no reason to believe that many of them would part from the brick. For this reason the laboratory test usually presents an exaggerated picture of the effect of thermal shock. A considerable amount of field work is required on the performance of insulating bricks in industrial furnaces, and the causes of their ultimate failure, before the part played by spalling can be properly assessed. From experience of this kind a more realistic spalling test might eventually emerge.

(d) Resistance to Slag Attack.—Insulating bricks are by nature susceptible to attack by slags and corrosive particles at high temperatures. It is rarely considered worth while to test their reaction to slag,

PROPERTIES OF SOME TYPICAL INSULATING BRICKS

Brick	*Main Constituent*	*Bulk Density (lb. per c. ft.)*	*Total Porosity (per cent.)*	*Thermal Conductivity at 500° C. Mean Temperature (B.U.)*	*Permeability to Air (c.g.s. units)*	*Cold Crushing Strength (lb. per sq. in.)*	*Shrinkage on Reheating for 2 hr. at Indicated Temperature (per cent.)*				*Spalling Resistance (Small Prism Test) (cycles)*	*Refractoriness under-Load (per cent. Subsidence in 2 hr. under 10 lb. per sq. in. at Indicated Temperatures)*	
A	Diatomite	32	76	1·11	0·04	130	900°C. 0·2	1,000°C. 2·0	1,100°C. 4·7		>30	900°C. 1·0	1,000°C. 2·6
B	Diatomite	46	67	1·40	0·002	440	850°C. 0·6	900°C. 1·5	950°C. 3·0		>30		
C	Vermiculite	29	84	1·65	5·27	100	1,050°C. 0·1	1,100°C. 0·3	1,150°C. 0·9		10		
D	Clay	32	81	1·67	1·22	200	1,150°C. 0·2	1,200°C. 1·4	1,250°C. 4·4		8	1,200°C. 6·0	
E	Clay	52	68	2·55	0·38	580	1,300°C. 0·2	1,350°C. 0·4	1,400°C. 0·9	1,450°C. 2·0	5	1,200°C. 0·9	1,300°C. 8·0
F	Clay	62	57	3·10	0·54	200	1,200°C. 0·8	1,250°C. 1·8	1,300°C. 3·9		>24		
G	Sillimanite	64	67	2·93	0·81	450	1,400°C. 0·0	1,450°C. 0·3			9	1,200°C. 0·18	1,300°C. 0·47
H	Corundum (alumina)	62	69	4·15	5·00	410	1,500°C. expansion 0·6	1,550°C. expansion 0·1			16	1,300°C. failed in 16 min.	
I	Mullite	54	73	2·27	4·10 0·90	190 90	1,500°C. 1·0	1,550°C. 2·8			10		
J	Clay	27	84	1·11			1,150°C. 0·0	1,200°C. 0·2	1,250°C. 0·6	1,300°C. 2·1	5		
K	Clay	41	76	2·35	10·5	125	1,300°C. 0·4	1,350°C. 0·5	1,400°C. 0·7	1,450°C. 2·5	9		

but some interest attaches to the protective effect of dense refractory coatings applied to insulating bricks. L. R. Barrett, W. F. Ford and A. T. Green[9] have described some experiments on these lines, in which they employed an apparatus devised by W. Hugill and A. T. Green.[10] This enables powdered slag to be fed into a gas—air blast flame directed on to the centre of the test piece at an angle of about 45°. The cutting action of the flame can also be studied in this apparatus.

(e) *Disintegration by Carbon Monoxide.*—The destructive action of carbon monoxide on the firebrick linings of blast furnaces is well known, but few instances of the disintegration of high temperature insulating bricks from this cause have to light. An experimental investigation has been carried out by L. R. Barrett, J. Vyse, and A. T. Green.[11] The disintegration is due to the catalytic effect of certain iron compounds in the brick in accelerating reaction

$$2CO = CO_2 + C$$

whereby carbon is deposited round the "iron spots" in such quantities as eventually to disrupt the brick. It is not yet known with certainty whether the active agent is metallic iron or iron carbide. In firebricks the effect is noticeable over the temperature range 300°-700° C. with the most rapid attack at 450°-500° C.

Insulating bricks should in theory be much more prone to disruption than firebricks, since their strength in tension is extremely low. The fact that they compare quite favourably with firebricks in resistance to attack by carbon monoxide may be due to their greater porosity, which will provide ample space for the innocuous deposition of carbon. The elasticity of the more porous structures may also play a part.

Test Procedure

Materials are tested for resistance to attack by carbon monoxide by heating a cylinder approximately 2 in. high and 1½ in. diameter to 450° to 500° C. in a horizontal tube furnace. A stream of carbon monoxide freed from traces of carbon dioxide and water vapour is passed over the specimen at the rate of 2·1 per hr. The specimen is examined periodically for general discoloration, carbon deposition at separate nuclei, and for cracking. The test is continued for 200 hr. or until the test pieces have disintegrated, whichever is the shorter period.

A more rapid method is available

in which a crushed sample of the material is used and the decomposition of the carbon monoxide is assessed by absorbing the carbon dioxide contained in the emerging gas and weighing it. It should be noted that the carbon monoxide used in this rapid test is saturated with water vapour, whereas in the longer test the gas dried. Moist carbon monoxide acts much more rapidly than the dry gas, and the presence of water vapour must be taken into account in considering the probable effect of furnace gases on the insulation. It has also been found that the presence of a proportion of carbon dioxide in excess of 10 per cent. has an inhibiting effect on the decomposition of carbon monoxide.

Insulating Powders, Granules and Concretes

Many of the standard tests cannot be applied to insulating powders and granules. In any case, the properties of these materials depend on the way in which they are used, particularly on the pressure used in packing them in position, since this determines the bulk density and hence the thermal conductivity. The packing density can be measured simply by weighing the powder required to fill a vessel of known volume under a selected packing procedure. The shrinkage on reheating can then be determined by heating the packed vessel and measuring the recession of the powder from its original level. Conductivity measurements on powders are rarely attempted, but a value can be obtained on some types of apparatus by flooring the specimen chamber with a sheet of nickel-chromium alloy to support the powder.

The author wishes to record his thanks to Dr. A. T. Green, O.B.E., Director of Research of the British Ceramic Research Association, for permission to publish this paper.

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ADVERTISERS' INDEX

This is an Arrow Press Publication. Published Monthly.
Subscription Rate 25s. per annum.
Published by Arrow Press Ltd at 29 Grove Road, Leighton Buzzard, Beds
Telegrams: Gastymes, Leighton Buzzard. Telephone: Leighton Buzzard 2328/9.

MADE AND PRINTED IN GREAT BRITAIN FOR THE PROPRIETORS, ARROW PRESS LTD., BY THE SIDNEY PRESS LIMITED, LONDON AND BEDFORD.